NOAA OFFICE OF OCEAN EXPLORATION

# EXPLORE

## 2004 Annual Report

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## MESSAGE FROM THE UNDER SECRETARY OF COMMERCE FOR OCEANS AND ATMOSPHERE & NOAA ADMINISTRATOR

2004 was a great year for the oceans and for NOAA Ocean Exploration! The Commission on Ocean Policy issued its historic report and President Bush responded with his Ocean Action Plan elevating ocean issues to the highest level. Meanwhile, NOAA's Ocean Exploration program continued to marvel and amaze the American public with key discoveries that have expanded our knowledge of what resides in our oceans.

NOAA's 2004 expedition season resulted in discoveries of new species and new ranges for known marine animals. Explorers observed an underwater volcanic eruption and liquid droplets of carbon dioxide rising from the seafloor. They studied deep-sea corals and associated habitats on underwater mountains and took a rare look at the interface of chemosynthetic and photosynthetic marine life. NOAA and Dr. Robert Ballard returned to the wreck of RMS *Titanic* in search of information to help marine archaeologists understand and protect this and other important shipwrecks of historical significance. The exploration team examined submerged cultural resources and a NOAA-sponsored team deployed a camera system to study marine life in unobtrusive ways. NOAA also organized multidisciplinary teams to explore and research deep corals off the Carolinas, a habitat that until recently very little was known about.

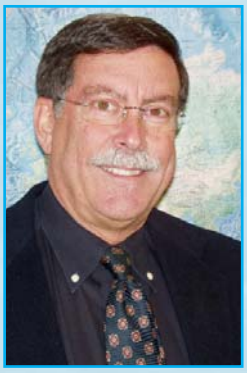
Because of scientific advances like these, people are starting to notice how important oceans are to every aspect of our lives from food, weather and climate, energy, new medicines, transportation and recreation. Of course, as with any scientific achievement, more questions are often raised. The challenge of uncovering our ocean's secrets is as vast as the ocean itself, but path-finding explorations to better understand, manage and protect our oceans are now underway.

In fiscal year 2005, NOAA's budget for ocean exploration increased substantially, up from about $13 million to approximately $22 million, and the President's request for fiscal year 2006 is at the $22 million level. NOAA recently took ownership of a former Navy ship to be converted as the nation's only vessel dedicated to ocean exploration and research. Coupled with the President Bush's Ocean Action Plan, these investments will expand our scientific knowledge of oceans, coasts and Great Lakes.

We still know more about the surface of the moon than we do about the bottom of the ocean. Thanks to the work detailed in these pages, that may soon change. NOAA is proud of our Ocean Exploration program and the value it provides to the country. We look forward to building upon the program's many successes as we continue the search the depths of the ocean for answers to many of life's greatest questions.

Conrad C. Lautenbacher, Jr.
Vice Admiral, U.S. Navy (Ret.)
Under Secretary of Commerce for Oceans and Atmosphere &
NOAA Administrator

## MESSAGE FROM THE ACTING DIRECTOR OF NOAA'S OFFICE OF OCEAN EXPLORATION



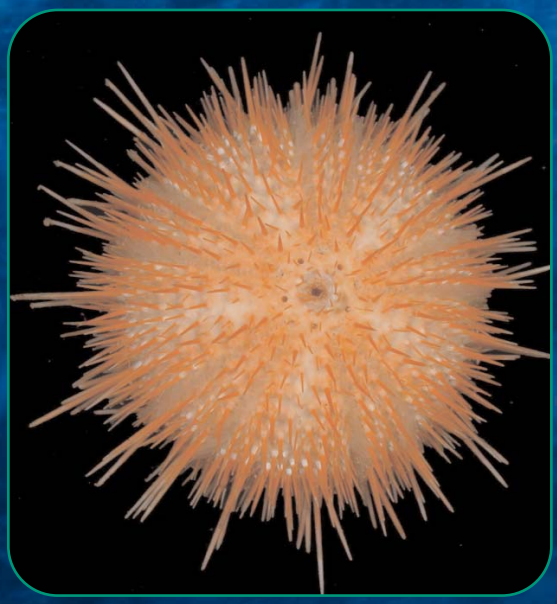
For three years, I've been privileged to serve as Chief Scientist for NOAA's Ocean Exploration (OE) program. In 2004, I was asked to become the program's Acting Director, following CAPT. Craig McLean's rotation to his next NOAA Corps billet, in the NOAA National Ocean Service. As this report is written, NOAA is in the process of selecting a permanent OE Director. Craig assembled a small but highly dedicated and talented team. Under his leadership, they made impressive progress toward realizing the ocean exploration goals in the 2000 report of the President's Panel, *"Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration."* Craig also enlisted the support of the U.S. oceanographic community for this new and exciting program of ocean exploration.

The OE program is bringing together scientist-explorers in interdisciplinary teams, providing them with research vessels and other special assets such as manned submersibles, remotely operated vehicles, and autonomous underwater vehicles. The program is also forging partnerships with oceanographic institutions, universities, and other ocean-related programs such as the National Ocean Partnership Program and the Consortium for Ocean Research and Education. Partnerships were also built within NOAA such as with the Arctic Research Office and the National Undersea Research Program, and with other federal agencies such as the National Science Foundation, National Parks Service, U.S. Navy and the Minerals Management Service. These partnerships are significantly enhancing the program's ability to provide ocean scientists of every discipline with unique, new opportunities to explore the oceans—especially in new areas—and to gain a much broader understanding of the ocean's ecosystems and biological, chemical, and physical environments.

OE will soon initiate routine use of a technology with great potential to enable more ocean scientists to participate in the program's expeditions, and to make the expeditions more accessible to students, educators and the public at large. This coming summer, an expedition to the Lost City vent field on the Mid-Atlantic Ridge will be conducted without the Chief Scientist of the cruise even being on board. This "telepresence" will be made possible by means of satellite-to-Internet2 connectivity to bring real-time, live video and audio from the ship and from remote vehicles on the ocean floor, to audiences ashore. This will significantly enhance the scientific capability of the expedition by adding shore-based scientists to the mission team. Coupled with OE's website (*http://oceanexplorer.noaa.gov*), live transmission of the expedition will also enhance the programs' mission-based curriculum and connect teachers and their students directly with the excitement of ocean exploration. This real-time broadband capability will be a standard resource for a new NOAA ship dedicated to explore the ocean, when the ship becomes operational in mid- to late-2007.

I hope you enjoy our Annual Report. If you have questions about or suggestions for our program, please contact me at: stephen.r.hammond@noaa.gov.

Dr. Stephen Hammond
*Acting Director, NOAA Office of Ocean Exploration*



# VISION AND MISSION

## THE VISION

The oceans are the lifeblood of Earth. They cover more than 70 percent of the planet's surface, drive its weather, and ultimately fuel all living creatures. Throughout history they have been a vital source for sustenance, transport, commerce, growth and inspiration. Yet for all of our reliance on the oceans we have explored less than five percent of their breadth and depth.

Realizing the urgent need for a better understanding of this critical global resource, and in response to growing national concern over the state of the oceans, the U.S. government empowered a panel of experts in 2000 to develop a national strategy for ocean exploration. The result was the creation of a National Ocean Exploration Program (OE) in 2001 to be led by the nation's ocean agency, the National Oceanic and Atmospheric Administration (NOAA).

In 2004, OE's vision was extended and sharpened when NOAA received from the Navy a vessel that will become, after 12 to 18 months in a shipyard, a state-of-the-art platform for ocean exploration.

## THE MISSION

NOAA's Office of Ocean Exploration was created to investigate the oceans for the purpose of discovery and the advancement of knowledge. NOAA's OE program signaled a turning point for this nation's ocean exploration efforts and it represents a bold and innovative approach. It infuses teams of multidisciplinary scientist-explorers with a "Lewis and Clark" spirit of discovery, and equips them with the latest exploration tools - some pioneered specifically to support OE missions. These new exploration tools are taking researchers to some of the deepest and least explored regions of the world's oceans and as a result, a more thorough understanding of the deep ocean realm is evolving.

OE's mission fits into four distinct areas:

- Mapping and characterizing the physical, biological, chemical and archaeological aspects of the ocean;
- Developing a more thorough understanding of ocean dynamics and interactions at new levels;
- Developing new sensors and systems to regain U.S. leadership in ocean technology, and;
- Reaching out to the public to communicate how and why unlocking the secrets of the ocean is well worth the commitment of time and resources, and to benefit current and future generations.

OE dedicates 10 percent of its annual budget to various outreach and education activities, and is committed to working towards improved science literacy and developing the next generation of ocean explorers, scientists, and educators. By tapping into NOAA's Ocean Explorer Web site and other outreach initiatives, Americans become "citizen explorers" and connect deeply with their own instinctive fascination with the oceans.

Expeditions and projects undertaken in 2004 were built on OE's previous three years of discovery-based ocean research. Results from the 2004 field season already include new maps of previously unknown ocean areas, the discovery of new marine species and habitats, and volumes of new data for scientists, natural resource managers and educators.

Please read on to learn more about the discoveries made and the new mysteries uncovered during 2004.

## EXECUTIVE SUMMARY

In FY 2004, OE operated with a budget of $13.1 million to support expeditions to unknown areas of the world's oceans, to develop and test new and evolving technologies, to bring the experiences of scientists at-sea and the information they were collecting into homes and classrooms, to organize and distribute data and information, to develop summary products and to support administrative and staff requirements. Sixty eight percent of the budget funded at-sea expeditions and other science-related projects – the heart of the NOAA Ocean Exploration program.

### FY 2004 BUDGET OVERVIEW

***At-Sea Expeditions ($7.9 million – 60%)*** At-sea expeditions explored for new and unique habitats, species and resources, and searched for signs of our sunken marine heritage. OE supported large-scale, multidisciplinary "voyages of discovery," and smaller-scale efforts to investigate mysterious phenomena such as communities of corals and sponges that grow at depths where sunlight does not penetrate. The investment included funding of grants to the explorers and expenditures for vessels, submersibles and other tools and technology that make this work possible.

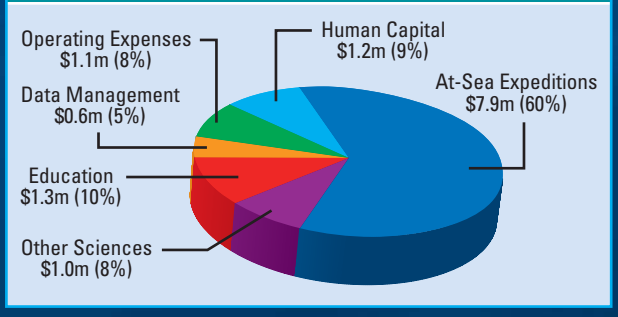
***Other Science ($1 million – 8%)*** – This category represented an investment in shore-based activities, including the development, testing, and evaluation of new and evolving technologies. It included projects related to developing Autonomous Underwater Vehicles (AUV), new mapping sensors, advanced underwater optics, and meetings and workshops where the results of exploration activities were discussed and presented, or where expeditions were planned.

***Education and Outreach ($1.3 million – 10%)*** – Because the ocean is a critical component of the global ecosystem, OE invested to advance ocean literacy among teachers, students, and other stakeholders. This included development of education products related to the at-sea expeditions – student lesson plans, teacher workshops, and school curriculums. It also included establishing partnerships with public and private organizations (museums, aquariums) that engage in ocean exploration and science activities, and supporting the award-winning NOAA Ocean Explorer Web site, oceanexplorer.noaa.gov.

***Data Management ($0.6 million – 5%)*** – Managing and disseminating data and information and developing a discrete set of products is essential to the program. OE leveraged its own resources with funding from other NOAA offices including the NOAA Library, the National Oceanographic Data Center, the National Geophysical Data Center, the National Undersea Research Program, the National Coastal Data Development Center, and others. Products included the "Expedition Information System," a Web-based Digital Atlas to display results and a catalogue of video footage from at-sea expeditions that is accessible through the NOAA Library.

***Operating Expenses and Human Capital ($2.3 million – 17%)*** – Operating expenses included expenditures for office space, equipment such as computers, and communications. Human capital expenses covered the NOAA Ocean Exploration program staff.

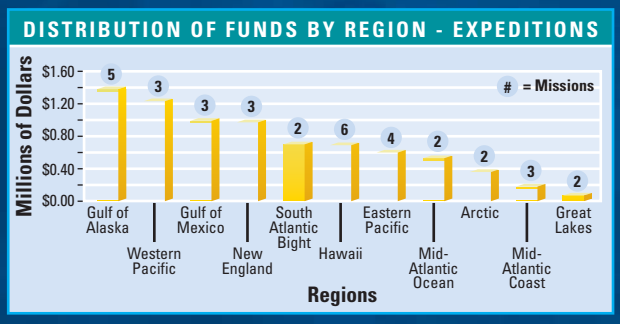
**EXPENSES BY BUDGET CATEGORY**



## AT-SEA EXPEDITIONS

The heart of the NOAA Ocean Exploration involves selecting, funding, organizing, conducting, and generating products from "Voyages of Discovery." Each year, the program solicits proposals that meet a specific set of exploration criteria, and makes selections through a peer-review process. Final decisions also factor in the availability of resources such as ships, submersibles and technologies.

***Geographic Distribution*** –In FY 2004, the majority of the investment and the greatest number of projects were conducted in the Gulf of Alaska. However, the program also invested in projects around the globe, from the Northwest Hawaiian Islands (an area as extensive as the continental United States), to the Mariana Arc, and the Black Sea. Investments vary greatly depending on the platforms and tools required and length of time at sea.




***Thematic Distribution*** – Thematic distribution of at-sea expeditions is a function of the proposal-driven process. However, OE seeks a well- balanced program in these themed areas:

- **Habitat Characterization** - These efforts focus on describing habitat and species/habitat relationships. Efforts can explore large regions or specific topographic features.

- **Corals** – These expeditions focus on collecting information on deep-water corals or unique shallow water coral systems. This includes efforts that describe coral habitat and species/habitat relationships.

- **Mapping** – These projects include low resolution (> 10m) surveying and mapping in areas that have never been surveyed, or high resolution (<10m) surveys of areas that have only been surveyed at low resolution.

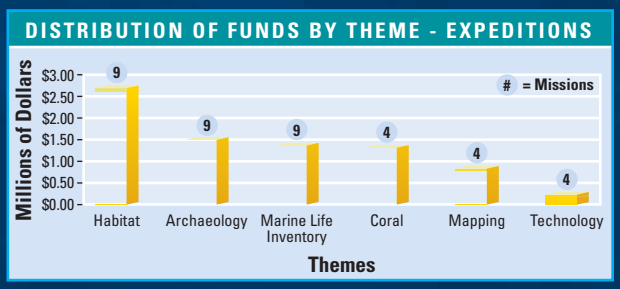
- **Marine Archaeology** – These efforts involve searching for suspected submerged cultural resources, and characterizing them once found. This includes, but is not limited to, wrecks of ships and submersibles, as well as areas of previous human habitation.

- **Marine Life Inventories** – Marine Life Inventory projects describe and quantify species population, diversity, distribution, and life history at regional to site-specific scales.

- **New Ocean Resources** – These projects locate, characterize, and collect organic and inorganic materials, and assess their commercial potential.

- **Technology** – Cruises that focus on technology involve developing, testing, and evaluating new undersea technologies that have the potential for improving future ocean exploration, research, management, and education.

- **Passive Acoustics** – These projects involve the application of passive acoustic technologies in new areas, or to new problems, i.e., to observe fish, marine mammals, and human activities in the marine environment.



# Ocean Exploration and Archaeology

## Discovery through systematic mapping and investigation

Systematic mapping and proven remote sensing techniques are cornerstones of the Office of Ocean Exploration, and serve as the operational foundation for the program's maritime archaeology activities. Focusing on the initial phases of marine archaeology – **discovery, investigation and inventory** – Ocean Exploration provided maritime heritage researchers with vessel time, advanced technologies and financial support in 2004 to explore for, research and better assess our nations' maritime heritage.

In 2004, Ocean Exploration (OE) supported coast research projects through academic partnerships with archaeology programs in a number of states. Objectives were to obtain a more accurate inventory of shipwrecks and other submerged cultural resources and to assess their historical significance.

Systematic mapping was a critical component of each project. One example was seen in the State of Maryland's project to use side scan sonar and magnetometer techniques to search for the War of 1812 British tender *HMS Mary*, lost in Chesapeake Bay.

In addition, OE supported East Carolina University's (ECU) Maritime Studies Program with two grants to investigate wrecks in collaboration with coastal states. One project investigated and confirmed the identity of an 1860 Russo-American trader, the *Kad'yak*, wrecked off its namesake, Kodiak Island, Alaska. The NOAA ship *Rainier* provided additional support by systematically mapping the *Kad'yak* area with advanced multibeam sonar technology.

With OE support, ECU also continued their inventory of shipwrecks near Cape Hatteras, North Carolina. In its third season, this database and remote sensing inventory has resulted in a large number of significant cultural resource finds.

OE also helped sponsor Stony Brook University's archaeological investigation of the Hudson River aboard the NOAA ship *Rude* using state-of-the-art hydrographic systems to discover and map items from the Revolutionary War era. This project marked the first time the *Rude* was "chartered" by an academic group, and the resulting partnership was valuable for NOAA, Stony Brook University and the State of New York.

OE continued to support programs internal to NOAA such as continual site mapping of wrecks located in Thunder Bay National Marine Sanctuary, and sponsoring an expedition with the National Undersea Research Center at the University of Connecticut to investigate the wreck of the USS O-9, a U.S. Navy submarine lost off the coast of New Hampshire.

Given the limited resources available to the maritime heritage community in the U.S., OE regularly collaborated with federal partners to leverage resources and best serve the shared goal of protecting historically important maritime sites. These partnerships included the National Park Service (NPS), the Minerals Management Service (MMS) and the Naval Historical Center (NHC).

In 2004, OE supported the Minerals Management Service with an archaeological and ecological expedition led by C & C Technologies Inc. The expedition in the Gulf of Mexico investigated a number World War II shipwrecks at various depths. Scientists wanted to determine the shipwrecks' impact on the environment, their rates of corrosion and the potential for the ships' propulsion fuel and their cargoes to adversely affect the environment. Scientists also studied the potential for decommissioned deep-sea oil drilling rigs and production platforms to serve as artificial reefs.

OE also supported the NHC center with two projects: mapping and locating sunken aircraft lost in Lake Michigan during World War II aircraft carrier training exercises, and using remote sensing equipment to locate the remains of the anti-slavery schooner USS Alligator off the Florida Keys.

Finally, OE supported an international reconnaissance investigation of historical American vessels off the coast of the United Kingdom near Filey Bay. Working with NPS, OE focused on a wreck site thought to be possibly the remains of *Bonne Homme Richard,* John Paul Jones' warship from the Revolutionary War. ■

# Marine Life Inventory – Census of Marine Life

Marine Life inventories describe and quantify species population, diversity, distribution, and life history at regional to site-specific scales. This includes projects that investigate, describe, and quantify vertebrates, invertebrates, macro-organisms and microorganisms.

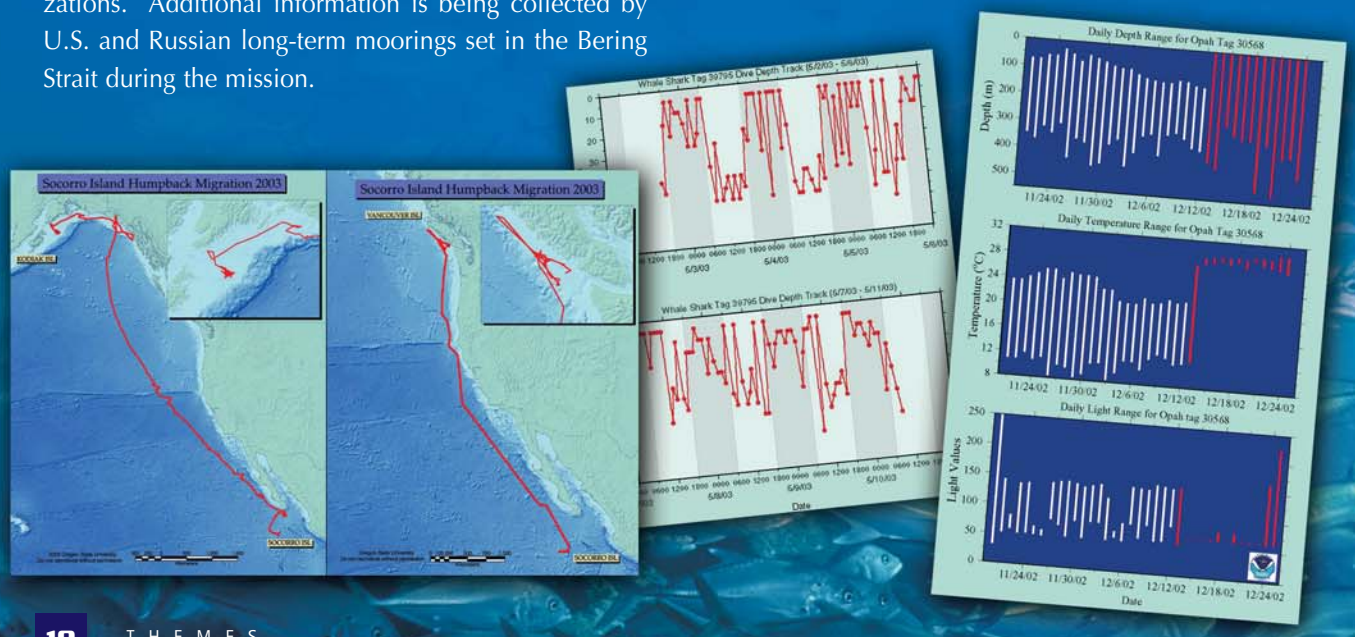
In 2004, NOAA's Office of Ocean Exploration supported the important objective to inventory marine life in a number of ways, spanning nine expeditions and projects. The office funded and helped organize expeditions large and small that specifically focused on marine life inventories and the Census of Marine Life (CoML).

Examples included supporting NOAA's Arctic Research Office with a major investment in a collaborative U.S.-Russian Federation mission, to help establish a baseline for a long-term census of marine life in the Arctic. The expedition, in July and August aboard the Russian R/V *Professor Khromov*, was the first mission following a Memorandum of Understanding signed by NOAA and the Russian Academy of Sciences. Data management for the 2004 expedition is being coordinated with National Oceanographic Data Center, the National Climate Data Center, the National Geological Data Center and the National Snow and Ice Data Center as well as with universities and other appropriate organizations. Additional information is being collected by U.S. and Russian long-term moorings set in the Bering Strait during the mission.

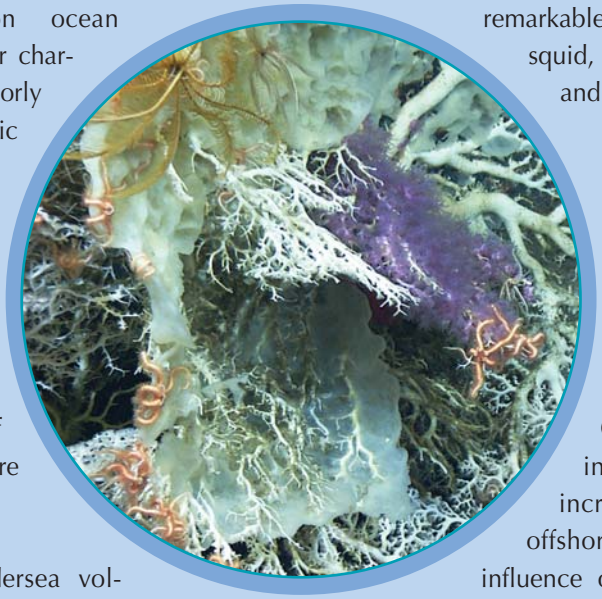
Another significant expedition to inventory marine life was "Operation Deep Scope" with Harbor Branch Oceanographic Institution and other partners in the Gulf of Mexico. This mission included the use of new camera and lighting technology to image deep sea marine life in new ways. In the past, bright lights and noisy submersibles likely have hampered the process of obtaining images of marine life for the purpose of building inventories. In Operation Deep Scope, a newly designed camera was placed on the seafloor with new and unobtrusive lighting to obtain images of animals in a more natural setting. In the very first hour the camera was in place, it imaged a six foot squid believed to be a new species.

Other projects that focused on Marine Life Inventories and directly or indirectly supported CoML included, "Hidden Life in Nearshore Alaska," where marine life was studied in ice cores; "Eastern Pacific Sharks" and a study of scavenger communities, both in Hawaiian waters; and a study of Mid-Atlantic Ridge diversity. In the New England region, the office supported a marine life inventories in the Georges Bank and an analysis of whaling records from times past.

In preparation for the 2005 field season, the office funded a major study of marine life diversity in the Banda Sea.



# Habitat Characterization



Many scientists on ocean expeditions this year characterized new or poorly understood benthic and pelagic habitats and ecosystems. Explorations included research on undersea volcanoes, deep-sea coral communities, the Arctic, bioluminescent life, an "estuary to abyss" transect, and the ecological effects of World War II shipwrecks. In each of these unique areas, habitats were assessed in some new way.

Habitats associated with undersea volcanoes were explored and characterized during the Submarine Ring of Fire cruise to the Mariana Arc volcanic chain in the western Pacific. Scientists studied unique habitats that thrive in or near extreme vent site environments. Initial findings revealed that macrofaunal communities vary greatly from seamount to seamount. Understanding this mosaic pattern will depend on more interpretation of the physical, chemical and geological setting.

Seamount habitats were explored during the New England Mountains in the Sea cruise where coral (primarily octocoral) aggregations were studied to determine their role in structuring seamount communities. Biodiversity of seamounts was assessed, examining the colonization dynamics of deep-sea corals and analyzing the distribution and abundance of deep-sea fishes associated with the seamount landscapes. Deep-sea coral samples were collected to help understand the relationships between the various taxa from various seamounts.

Operation Deep Scope took a fresh approach to observing habitat. Through technological advances in imaging, researchers used a new "technological eye" to observe and characterize habitats. Unobtrusive technologies let them see animals and behaviors never before witnessed by humans, revealing many remarkable visions, such as a deep-sea squid, fluorescent fish and animals, and flashing corals.

During the Estuary to the Abyss expedition, scientists explored along a virtual transect in depths from 400 to 1000 meters, from the coast of Georgia to the edge of the continental shelf off South Carolina. They examined changes in faunas that occur with increasing depth and distance offshore to help understand the influence of distance from land (and its human inhabitants), bottom type, and overlying water masses.

On the second leg of the Russian-American Long-term Census of the Arctic (RUSALCA), scientists focused on ecosystem-oriented exploration. The Arctic shows a trend in reduction of ice cover in the Chukchi Sea study region and scientists believe this area might be subject to significant ecosystem change. The RUSALCA studies will provide a foundation for detecting future changes. Scientists examined fish distribution, other water-column and benthic (sea-bottom) biological exploration, nutrient and current fluxes, methane distribution and sea-floor processes.

The Gulf of Mexico Shipwreck Survey Expedition with MMS had a significant biological component. Scientists studied how man-made structures may function as artificial reefs in deep water. Objectives were to characterize the biological effects, namely concretions and biofouling communities on each wreck, and determine the extent of physical and biological modification of sediments through the activity of microbes near the wrecks compared to distant areas. The study also evaluated motile fish and invertebrate associations with microbiologically induced concretions, hard pans, and other growth forms. ■

# Deep-Sea Corals

More exploration and research has recently begun to search, map, and study deep-sea coral communities in a systematic way. Deep-sea corals are fragile, long-lived, slow-growing, and extremely susceptible to physical disturbance. It is unknown if these species would be capable of repopulating a given area if they are destroyed. Little is known about their distribution, population dynamics, ecology, or how they function as habitat for other species. As human activities such as fisheries and oil and gas exploration expand into deeper waters, the need for deep-sea coral exploration and research grows more critical.

Information from exploration has described the species and community structure in a given area, the health of the system and effects of human activities such as evidence of physical destruction from trawl gear. This information is used to organize research and monitoring, and to invoke management measures. For example, the results of exploration activities have been used very effectively to help establish the Oculina Habitat Area of Particular Concern (HAPC) off the east coast of Florida.

In 2004, OE supported a number of missions to locate and study deep-sea corals. On an expedition to the Gulf of Alaska, three Principal Investigators researched

different aspects of deep-sea corals, and later, one of those scientists led a "Deep-Sea Precious Corals" expedition in Hawaiian waters. The study of deep-sea corals and their associated communities was also a key part of an expedition to New England Seamounts, and was a focus in another expedition, "Life on the Edge." Additional expeditions included deep-sea corals in a rich mix of research themes. For example, "Estuary to the Abyss" collected dead corals to study their growth rings as potential markers of regional weather and climate patterns in past decades or centuries. This data could be useful in predicting regional weather and climate.

Working with states and academic institutions, NOAA has taken a leading role in expanding exploration for and research on deep-sea corals for the purposes of effective management. Much work remains to be done since so little is known about deep-sea coral habitats. Exploration will continue to play a crucial role in providing scientists, natural resource managers, and educators with the first records and descriptions about these systems. Ocean explorers will be called upon to provide a framework and foundation of information that will fill existing gaps in our knowledge, and to set the stage for refined research, management, and monitoring. ■

# New Ocean Resources

New Ocean Resources is a theme found in expeditions designed to locate, characterize, and collect organic and inorganic materials, and assess their potential as resources. Many of these efforts focus on collecting unique deep-water specimens of invertebrates and microbes and isolating potentially bioactive compounds that could be developed as pharmaceutical products or biomedical research tools.

The ocean is home to the greatest biological diversity on the planet. While the most common use of marine animals and plants is for food, they also produce a wide variety of chemical compounds of increasing interest to explorers and scientists as potential biomedical agents. Marine plants and animals adapt natural biochemicals in a variety of ways to produce any ecological edge they can find to survive in a highly challenging ocean environment.

The bounty from the sea includes chemicals and biological materials isolated from marine organisms, which are currently commercially available or in development as pharmaceuticals, molecular probes, medical devices, diagnostics, enzymes, nutritional supplements, pigments and cosmetic additives.

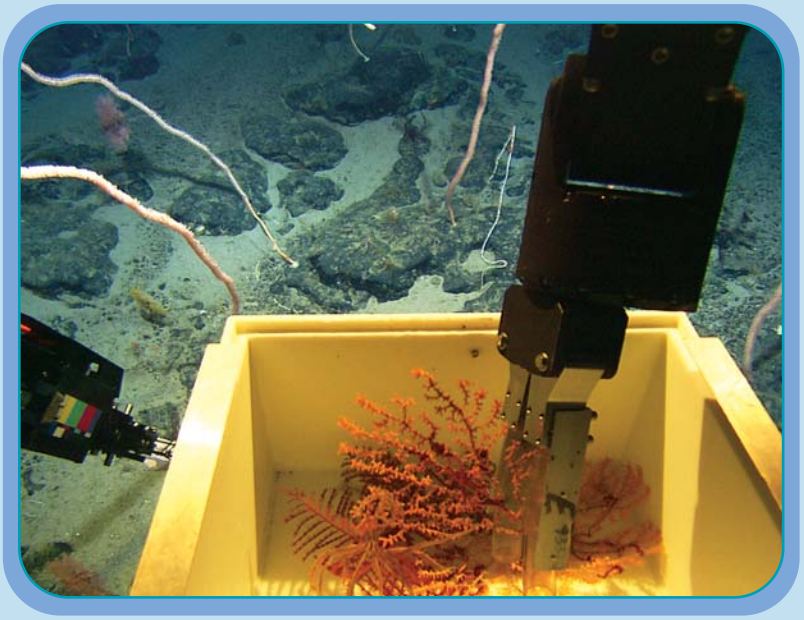
The 2004 Gulf of Alaska Seamount Expedition used the deep submergence vehicle (DSV) *Alvin* to explore five large seamounts. Giacomini, Pratt, Welker, Denson, and Dickens seamounts stretch over a 400-nautical-mile section of the northeast Pacific, called the Kodiak-Bowie Seamount Chain. Operating from a base aboard the R/V *Atlantis,* scientists dove to depths of up to 3,500 meters to conduct biological and geological investigations on those ancient volcanoes. One focus was on bamboo corals, and the lead scientist in that area is interested in bamboo corals for many reasons, including their application as bone replacements. Since the architecture and chemistry of corals are very close to human bone, some coral already has been used to replace bone grafts in helping human bone to heal quickly and cleanly.

Scientists on a number of missions sponsored by NOAA's Office of Ocean Exploration (OE) collect and preserve specimens for later additional research, including investigation of marine compounds as biomedical agents. OE has begun a review of the additional costs, equipment and procedures needed to expand the collection of specimens on ocean expeditions, store and protect them properly and disseminate them to a wider audience of scientists interested in researching marine animals for beneficial medical or industrial use.

Another potential new ocean resource is methane hydrates, solid ice-like structures of water and natural gas located beneath the ocean floor. Conservative estimates of methane hydrates in U.S. waters indicate volumes of natural gas sufficient to supply all the nation's energy needs for 2,000 years at current use rates. On an OE-sponsored mission in the Gulf of Mexico, a scientist from the University of Florida, unexpectedly discovered that methane hydrates are brilliantly fluorescent. Knowledge they fluoresce could lead to new detection techniques. ■

# Ocean Exploration Technology – New Sensors and Tools

The ocean, just like outer space, demands advanced technology for exploration and research. With technical excellence a core value at NOAA's Ocean Exploration (OE) program, OE works to foster the development and deployment of state-of-the-art ocean technologies.



The technology program is very much a collaborative effort with engineers at leading institutions and industries across the nation. Strong ties to technology development labs keep OE's technology program at the cutting edge of ocean engineering.

Cooperation across government agencies, industry and academia is designed to maximize the impact of technology investment. OE does not support technology development for its own sake but is always driven by a defined need. This may be a particular scientific question or an apparent technological need.

As new tools are developed they should be made available to all ocean explorers. But not all new technologies are field proven. OE's limited budget generally prohibits long-term investments in technology development. Rather, OE aims to provide support for highly leveraged projects and the first field tests of new technologies. OE provides technical expertise and leadership, thereby improving all aspects of NOAA's ocean research, management and exploration efforts.

The OE technology program works through a variety of mechanisms. Joint programs with other Federal agencies, direct grants to academic and industrial research teams, and internal partnerships with other NOAA programs allow for a diversity of technology projects. During 2004 many exciting pilot programs, demonstrations, and development efforts were conducted in the OE technology program.

The program supported significant new technologies or trials of new tools. Grant funding supported research into new artificial intelligence for autonomous underwater vehicles (AUVs). Grants also moved new chemical and biological sensors from lab prototypes to field trials. Certification of AUV "gliders" for deployment from research aircraft was another extramural program, as was advanced research into quantitative measurements of ocean features using video cameras.

Working with the U.S. Navy, OE demonstrated a new imaging system on an AUV. A multi-agency team used this vehicle and instrument to examine the wreck of the Paul Palmer in the Stellwagen Bank National Marine Sanctuary. Another joint project explored the technology required to allow unmanned marine vehicles to interact with conventional vessels.

Within NOAA, OE continues to provide leadership and technical expertise in the area of AUVs. During 2004, NOAA took delivery of two AUVs and contracted for a third. OE was engaged in each of these projects, directly supporting NOAA colleagues as they develop and deploy these new tools. ■

# New Exploration Ship

A new NOAA ship will go boldly on a mission to further explore the world's oceans. A multidisciplinary group is on a fast track to plan and develop specifications for a major conversion of the former Navy ship USNS *Capable*. Following the award of a conversion contract and an estimated 12 to 18 months in a shipyard, the ship will be unique to NOAA and the federal fleet as the only U.S. government ship dedicated to exploring Earth's oceans.

"We want NOAA's newly converted ship to become the international symbol vessel for ocean exploration and research," said Stephen Hammond, acting director of NOAA's Office of Ocean Exploration. "When it sails to unknown areas of the ocean, chances are excellent that multidisciplinary, international teams of scientist-explorers on board, and on shore at satellite-linked Science Command Centers, will make very fundamental discoveries. If we plan well now, those scientists will be equipped for success," said Hammond. "It will be a path finding ship for discovery, and for mapping a route to ocean research."

"We are excited about the possibilities this ship offers," said Rick Rosen, NOAA Assistant Administrator for Oceanic and Atmospheric Research. "While research largely involves the testing of hypotheses, scientists on this ship will do that and more—they'll be testing, but also generating, hypotheses."

Key elements of converting the ship will be mounting a multibeam mapping sonar on the bottom of the hull and equipping the ship with a dynamic positioning system, or DP, because it's vitally important that the ship maintains position while operating remotely operated vehicles (ROVs). DP links ship instruments measuring wind, speed and currents, with a Global Positioning System reading from satellite. The system then automatically adjusts the ship's main and thruster engines to keep the ship in a very tight circle, no more than 10 meters off target.

After conversion, the 224-foot former Navy ship will be NOAA's only ship with a dedicated science-class deep-ocean robot. The ship will carry 10,000 meters of umbilical cable, weighing more than 22,000 pounds. Up to 6,000 meters will be used to lower a tow sled close to the ocean floor. Another 30 meters of separate cable will connect the tow sled with a mobile ROV equipped with a robust sampling capability. The long umbilical from the ship to tow sled will funnel commands to and collect data and images from the ROV. And, it will provide both the tow sled and ROV with enough electrical power to operate bright lights, high-definition video cameras and high-resolution still cameras.

Scientists who miss the ship need not stand on the pier and watch opportunity sail away. They will be ashore at special Science Command Centers, one of which will be built at NOAA's Silver Spring complex. Though far from a rolling ship, those scientists will be members of the science team—full participants in the ocean expedition. Through high-speed Internet2 connections, scientists will exchange data and see deep-ocean images and specimens taken by ROVs at the same time as their counterparts on the ship, or at other Science Command Centers ashore. ■

# Education and Outreach

With 10 percent of its overall annual budget dedicated to education and outreach, the Ocean Exploration (OE) program strives to engage the broadest possible audiences so as to raise America's environmental literacy. During 2003-2004, OE continued to form collaborations among explorers and educators to develop educational opportunities, materials, and resources that brought entire classrooms "on board" for exploration and discovery during NOAA's multidisciplinary voyages.

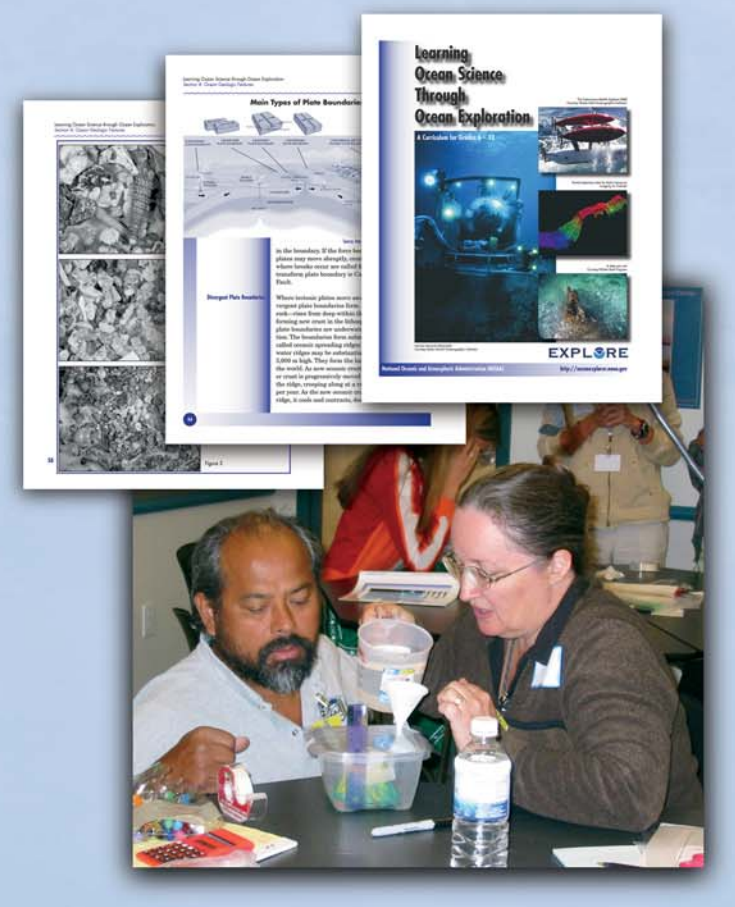
Eighteen lesson plans were produced for six multidisciplinary voyages of discovery and were posted under the Education Section of the Ocean Explorer Web site *oceanexplorer.noaa.gov*. Lesson plans were correlated to the National Science Education Standards and were enhanced with daily logs from sea prepared by scientists and educators. Images and video captured in the daily logs also provided an invaluable opportunity for teachers and students to glimpse new ocean findings, often within 24 hours of their discovery. A total of 75 teachers; representing a minimum 2,250 students in SC, GA, MS, and MA; participated in intensive professional development in the use of the lessons. They brought NOAA science and exploration into classrooms and provided students with opportunities to look into the lives and careers of premier ocean scientists/explorers on expeditions from the western Atlantic and Gulf of Mexico to the western and eastern Pacific Ocean.

Collaborations with the NOAA National Ocean Service (NOS) Special Projects staff led to OE Education Alliances becoming an added feature on the Ocean Explorer Web site at *oceanexplorer.noaa.gov/edu/alliances/welcome.html*. Professional development offerings continued to be added at *oceanexplorer.noaa.gov/edu/development/development.html*. Ocean A.G.E Careers (Another Generation of Explorers) at *oceanexplorer.noaa.gov/edu/oceanage/welcome.html*, continued to develop with two new career profiles and web chats added. There, students interact via live Web chats with talented women and men who explore our ocean planet. From submersible pilots to research scientists, the site provides students with first-hand knowledge of exciting ocean careers through live interviews, video profiles, biographies, background materials, and mission logs. An Ocean Explorer Education Listserv was developed and currently has more than 3,500 subscribers who are informed of upcoming professional development and other educational offerings, including NOAA Ocean Exploration Expeditions.

The final phase of *Learning Ocean Science through Ocean Exploration* was completed with printing of the curriculum which serves as the cornerstone for national-level professional development in ocean science content for teachers of Grades 6-12. OE Education Alliances established with the Monterey Bay Aquarium Research Institute and Audubon Aquarium of the Americas in 2003 continued to offer professional development in the use of the curriculum, and three new Alliances were established with the South Carolina Aquarium (Charleston, SC), the New England Aquarium (Boston, MA), and The Pier Aquarium (St. Petersburg, FL).

In addition to these formal partnerships, professional development in the use of the curriculum was offered at the National Marine Sanctuaries Annual Workshop (Honolulu, HI), Louisiana Science Teachers Association Short Course (New Orleans, LA), Alaska SeaLife Center (Seward, AK), Center for Ocean Science Education Excellence – Southeast Summer Institute and Port Day (Savannah, GA and Charleston, SC), and the National Science Teachers Association Annual Conference Short Course 2004 (Atlanta, GA). In all, 301 teachers were reached, representing a minimum of 9,030 students.

In partnership with the National Marine Educators Association (NMEA), OE coordinated development, editing, and layout and design of two issues of *Current: The Journal of Marine Education*: one focusing on *Aquarius* and another on the Proceedings of the 2004 NMEA Annual Conference. *Current* is distributed to more than 1,200 NMEA members throughout the country. OE also developed an educational brochure, entitled National Oceanic and Atmospheric Administration (NOAA) Ocean Exploration Education Program. More than 8,000 have been distributed at professional conferences around the country.




OE, in partnership with the National Geographic Society and the College of Exploration, hosted a 9-part virtual teacher workshop series, entitled *Classroom Exploration of the Oceans 03: Ocean Exploration – H.M.S. Challenger and Beyond* to identify how the excitement of ocean exploration can enhance teaching and learning in the classroom. Approximately 2,100 teaching professionals, representing 48 U.S. States and 50 different countries, territories, or organizations, including the Department of Defense Schools, Puerto Rico, Guam, American Samoa, Northern Marina Island, and the U.S. Virgin Islands; participated in the workshop.

NOAA OE continued to foster numerous national and regional partnerships with scientific and educational organizations to enhance ocean literacy. These include, but are not limited to, the Marine Advanced Technology Education national ROV student competition, the National Centers for Ocean Science Education Excellence (COSEE) Council, the Southeastern COSEE, the Girl Scouts of the U.S.A, and the Smithsonian Institution's National Museum of Natural History (NMNH) Ocean Hall, a premiere exhibit on the global ocean to open in 2008. Additionally, OE worked closely with the Marine Technology Society. The OE Education Director worked closely with the NOAA Center of Excellence in Oceans and Human Health at the Hollings Marine Laboratory, served as a member of the NOAA Education Council, and worked closely with the NOAA Office of Education and Sustainable Development.

When NOAA's new ship for ocean exploration becomes operational as expected in 2007, it will be a platform not only for ocean exploration and science, but also for education. An exciting aspect of the ship will be its ability to send live audio and video images from scientists at sea, and images from robotics on the ocean floor to classrooms, making teachers and students virtual members of each team of scientist-explorers. The satellite-Internet pathway into classrooms will be complimented in many cases by daily logs filed by scientists from sea, and opportunities for students to ask questions of scientists via email. Additionally, as the ship is designed for its conversion, an important consideration is how the vessel can best be equipped to host teacher professional development.


The outreach component of Education and Outreach is communicating to a variety of audiences, some large and some narrowly defined and targeted, the importance of, and the need to explore, Earth's ocean. One outreach goal in 2004 was to interest reporters at major media organizations to cover our ocean expeditions, by offering and explaining news coverage opportunities that connect directly with their audiences. This begins with the fact all life depends on the ocean.

Reporters from national and international media organizations covered many key ocean expeditions sponsored by NOAA's Office of Ocean Exploration during the 2004 field season. A media event at the National Press Club was arranged for scientists to explain their extraordinary discoveries on the Submarine Ring of Fire. Associated Press wire service, Associate Press television, Voice of America, EOS Newspaper, and others covered the event directly and carried a story picked up by Fox television, ABC's "Good Morning America" and many other outlets.

A live satellite media availability was held for reporters ashore to interview scientists at sea during the 2004 Mountains in the Sea mission, and Associated Press and other media extensively covered expeditions such as Life on the Edge, Windows to the Deep, Investigating the Charleston Bump, Operation Deep Scope, Gulf of Alaska and others. A Reuters reporter sailed with the U.S.-Russian expedition to the Arctic, and filed three lengthy stories.

Return to *Titanic* saw extraordinary coverage including a National Geographic television special with Dr. Robert Ballard who discovered the wreck in 1985. News releases about NOAA's participation in identifying Kad'yak, the oldest shipwreck yet discovered in Alaska, started with coverage in the New York Times and quickly became an international wire story, and the discovery of the wreck of a large Navy seaplane that sank off Hawaii, was covered nationally.

Eleven media events were conducted in association with 2004 ocean expeditions. These events and other created media opportunities focused on advancing ocean literacy, interesting young people in the joy of discovery and the possibility of marine science careers, and importantly, encouraging all audiences to obtain more information by visiting our primary outreach resource, *oceanexplorer.noaa.gov*.

Outreach efforts went beyond traditional media to include developing with our Web team an Ocean Challenge Puzzle, and coordinating an ocean exploration story in Mark Trail, the comic-strip star who has been teaching people to preserve our natural resources for future generations. Mark Trail appears in 175 newspapers, reaching nearly 23 million readers worldwide.

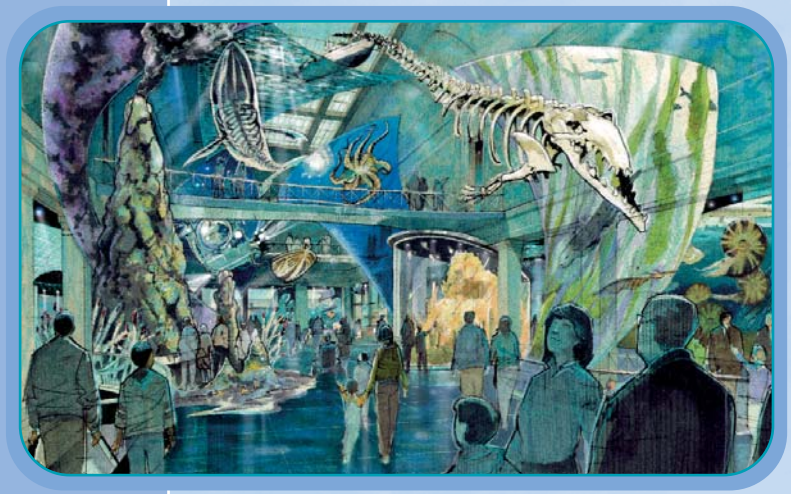
Ocean exploration education and outreach will extend its reach enormously with new Science Centers under construction ashore that link by Internet2 and satellites to our ships exploring at sea, and with exploration ships showing images from the seafloor in real time over basic Internet, to reporters, teachers, students and armchair explorers ashore. ■

# OCEAN HALL

***Vast, diverse, deep, dark, powerful, mysterious….magical!.*** That's what you get when you ask scientists, researchers, educators, and designers from schools, government agencies, museums and aquaria to describe the ocean in a single word. The one-word descriptions launched plans for Ocean Hall, a partnership between NOAA and Smithsonian to create a major exhibit to open in 2008 in The Smithsonian Institution's National Museum of Natural History. Those first words expanded into themes for educating and inspiring the public—ocean stewardship, an awareness of our human connection to the oceans, the global ocean, ecosystems, and for nurturing the next generation of ocean scientists and policymakers.

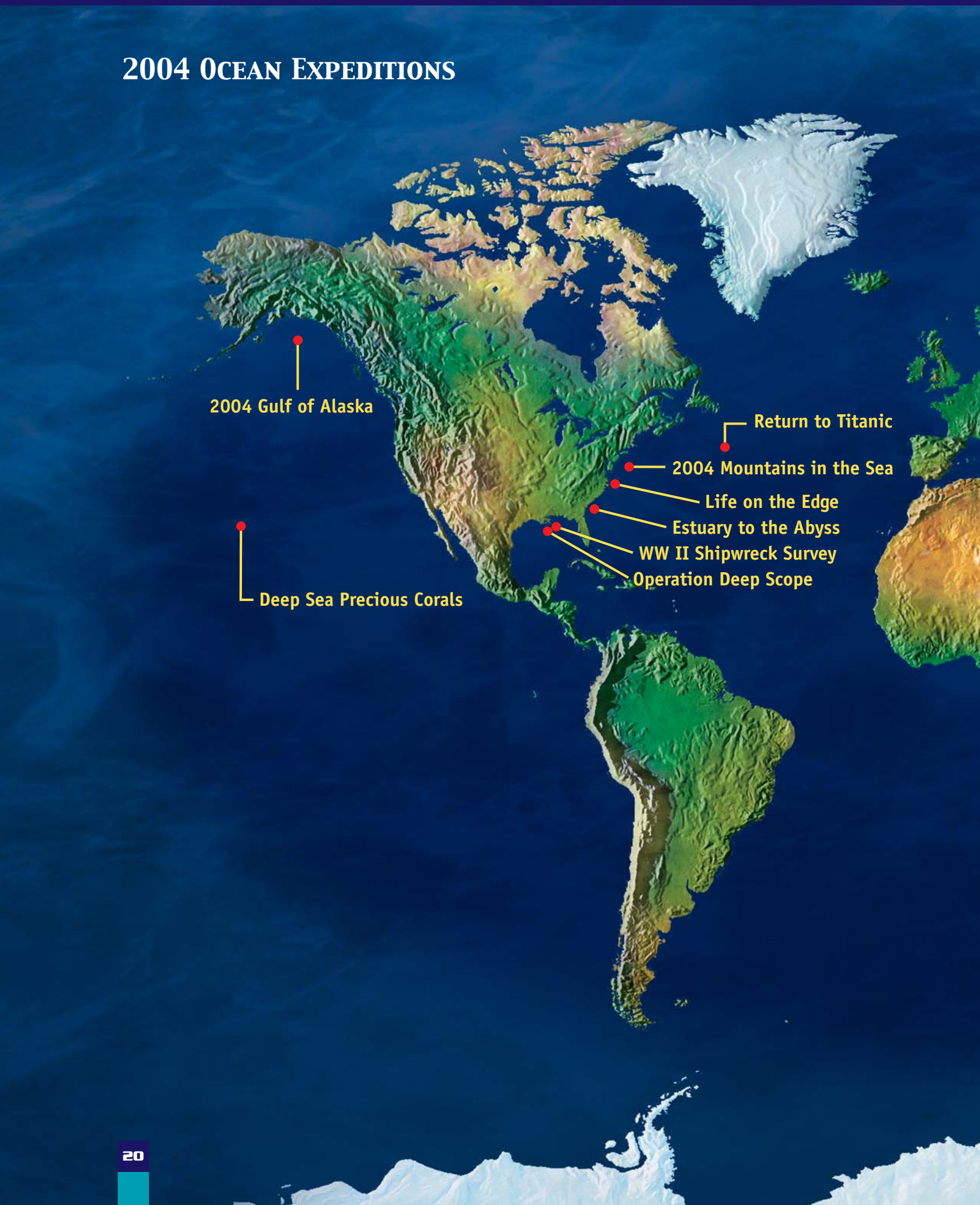
"I grew up in this area. I remember Smithsonian's old Marine Hall with a model of a huge blue whale hanging from the ceiling. I was always so excited to go there," said Joanne Flanders, NOAA's Ocean Hall project manager. "It's a real opportunity to plan for an ocean exhibit that's much larger and scheduled to last 30 years, because I want children who will visit, and their children, to have that same magical experience I had."

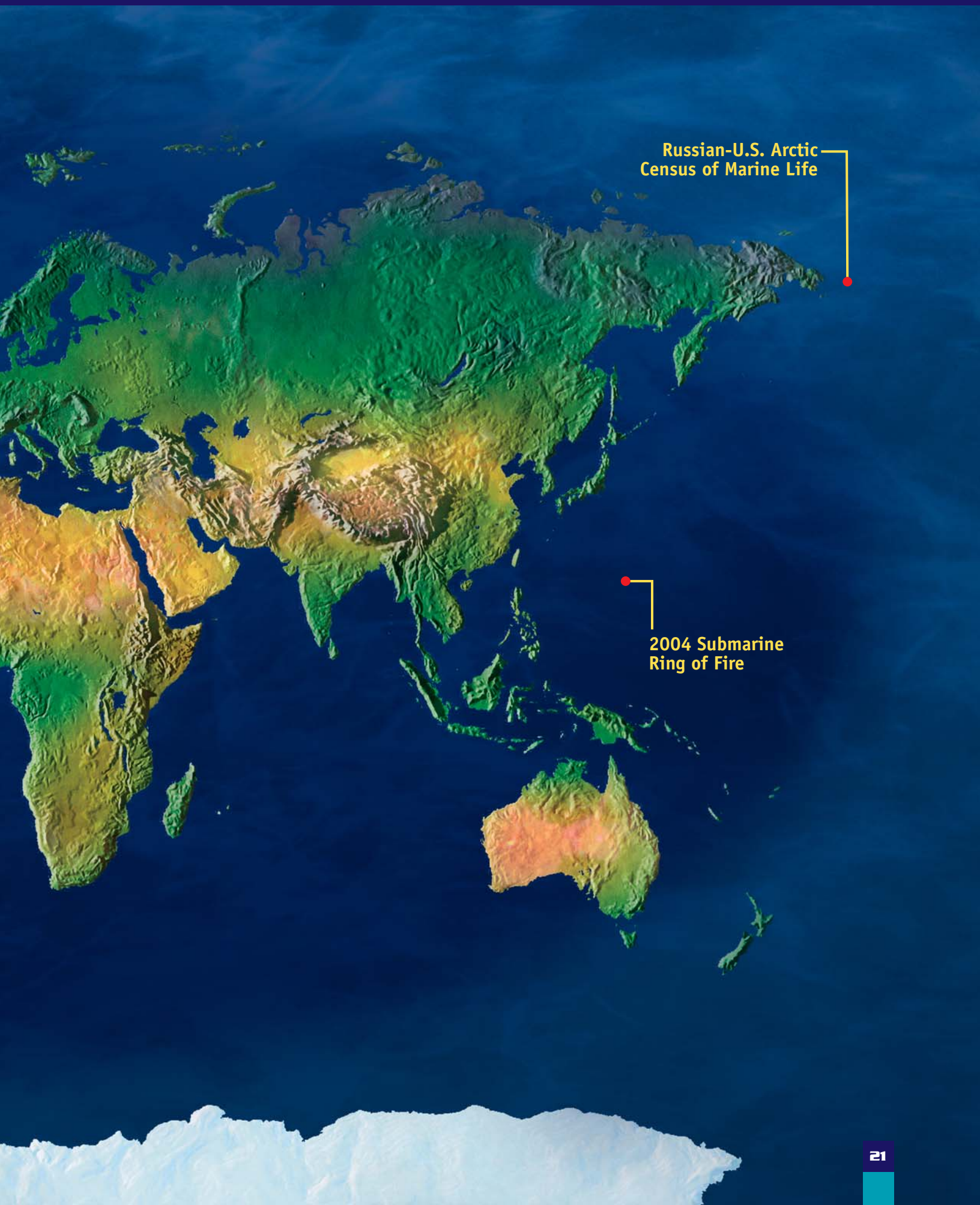
In Ocean Hall, a large icon exhibit will be a model of an endangered North Atlantic right whale. Visitors will get a plankton's eye view of the feeding giant whale whose head will be coming down quite low into the Hall. The Hall will also likely include NOAA's "Science on a Sphere" with eight cameras and high-intensity lights projecting on a six foot sphere, simulating a view from 22,000 miles above the Earth. Projections will tell stories of a global and interconnected ocean interacting with the atmosphere, changing with plate tectonics, and producing oxygen, food and medicine. "The sphere will be engaging—a real eye-catcher," Flanders said. "With the effect of ocean currents, storms and other dynamics moving across a spinning globe, people will understand almost immediately that our ocean is a dynamic, global system."



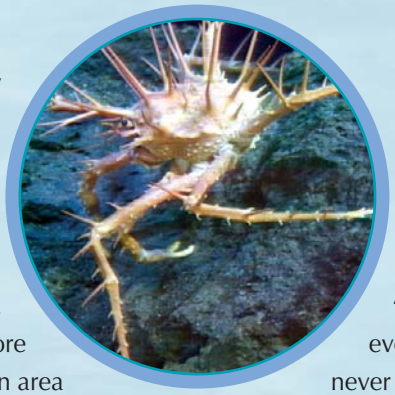
Plans include an Ocean Exploration Theater where visitors will take a simulated deep-ocean dive. Other exhibits will show interactions of the ocean's biology, chemistry and geology and will demonstrate the ocean's connections to life on all parts of the planet. "Plans include an 'Ocean in the News' exhibit with video news updates by NOAA or Smithsonian scientists," Flanders said. Shores to shallows, bio-luminescence, a vertical water column showing diversity, and a coral reef tank are also planned. "When we first began," said Flanders, "a number of us said we wanted Ocean Hall visitors to get the 'feeling' of the ocean. If visitors come away more educated and excited about the ocean, and just a bit in awe of an ocean on which life—including their life—ultimately depends, Ocean Hall will put up the 'success' sign," she said. "And it will be the ocean itself that will benefit.

# 2004 Ocean Expeditions




Russian-U.S. Arctic
Census of Marine Life
2004 Submarine
Ring of Fire


# Submarine Ring of Fire



Submarine Ring of Fire–2004, a 21-day voyage of discovery was sponsored by the National Oceanic and Atmospheric Administration and by the Natural Sciences and Engineering Research Council of Canada. The mission joined 34 top scientists from the U.S., Canada, Japan and New Zealand to explore submerged volcanoes of the Mariana arc, an area extending northward from Guam for nearly 760 miles. The science team initially mapped the area in 2003 when they surveyed more than 50 submarine volcanoes and discovered that 10 of them had active hydrothermal systems.

"Our primary interest in studying these volcanoes is their relatively shallow depth," said Bob Embley, the mission's chief scientist and an oceanographer with NOAA's Pacific Marine Environmental Laboratory. "In contrast to the great depths of most of the mid-ocean ridge volcanoes, these volcanoes commonly rise into the upper reaches of the oceans where most marine life is concentrated and where exchanges in gases take place with the atmosphere."

A key objective was to characterize the biology and chemistry of the hydrothermal systems at Mariana Arc volcanoes. Sea-floor hot springs are well known along the mid-ocean ridge system, because they were first discovered more than 25 years ago. In comparison, the hydrothermal systems of submarine volcanoes along island arcs are relatively unexplored, especially in terms of modern exploration tools.

The mission relied heavily on the unmanned submersible Remotely Operated Platform for Ocean Science (*ROPOS*) to probe the depths down to more than a mile where human exploration is limited. *ROPOS* was launched and guided from the University of Washington Research Vessel (R/V) *Thomas G. Thompson.* Scientists made 14 dives with the submersible on seven volcanoes and collected hundreds of samples for geological, biological and chemical studies.

"We were just going from one incredible event to the next, seeing things we had never witnessed before," said Bill Chadwick, a volcanologist with the Cooperative Institute for Marine Resources Studies at Oregon State University. "It was exciting and quite remarkable in that every volcano we visited was unique."

A dramatic discovery was made at the first site visited. The unmanned submersible *ROPOS* and its cameras were 1,800 feet deep on the rim of a crater near the top of a volcano when huge yellow clouds of sulfur-rich effluent enveloped the submersible.

"We aptly named this site 'Brimstone Pit,' and when rocks emerged from the cloud hitting the *ROPOS*, we realized we were the first to witness a deep-sea volcano during an eruptive episode," Embley said. "It was fortunate we were there to observe and sample it, but it was difficult to take samples in the volcanic crater because of the danger to the *ROPOS*."

NOAA scientist Dave Butterfield, chemist in charge of water sampling, determined that the fluid was very corrosive, with a high concentration of sulfuric acid. The *ROPOS* operator on the research vessel sent a signal down the long tether line, commanding *ROPOS* to reverse engines.

At another site, a spectacular, highly concentrated flow of carbon dioxide-rich fluid was discovered. The science team was astonished to see large bubbles floating up from the seafloor around this site when it was disturbed. After discussion, the consensus opinion was that the bubbles were predominantly liquid carbon dioxide. This is a key discovery not simply for the novelty of the phenomenon.

"We found a natural laboratory where the effects of carbon dioxide on marine organisms can be studied," said Steve Hammond, acting director of NOAA's Office of Ocean Exploration. The liquid form of carbon dioxide is present due to the great depth, and resulting pressure at the site. At 5,263 feet (approximately one mile), the pressure from the water column is equal to 160 atmospheres.

NOAA scientist John Lupton, the principle investigator studying the gases, teamed with others to collect the bubbles in an inverted plastic tube normally used for taking sediment samples. Some bubbles were then drawn into a special gas-tight titanium bottle.

Hydrothermal activity on submarine volcanoes also fed large populations of microbes specially adapted to use iron, hydrogen sulfide and other chemicals for their energy source.

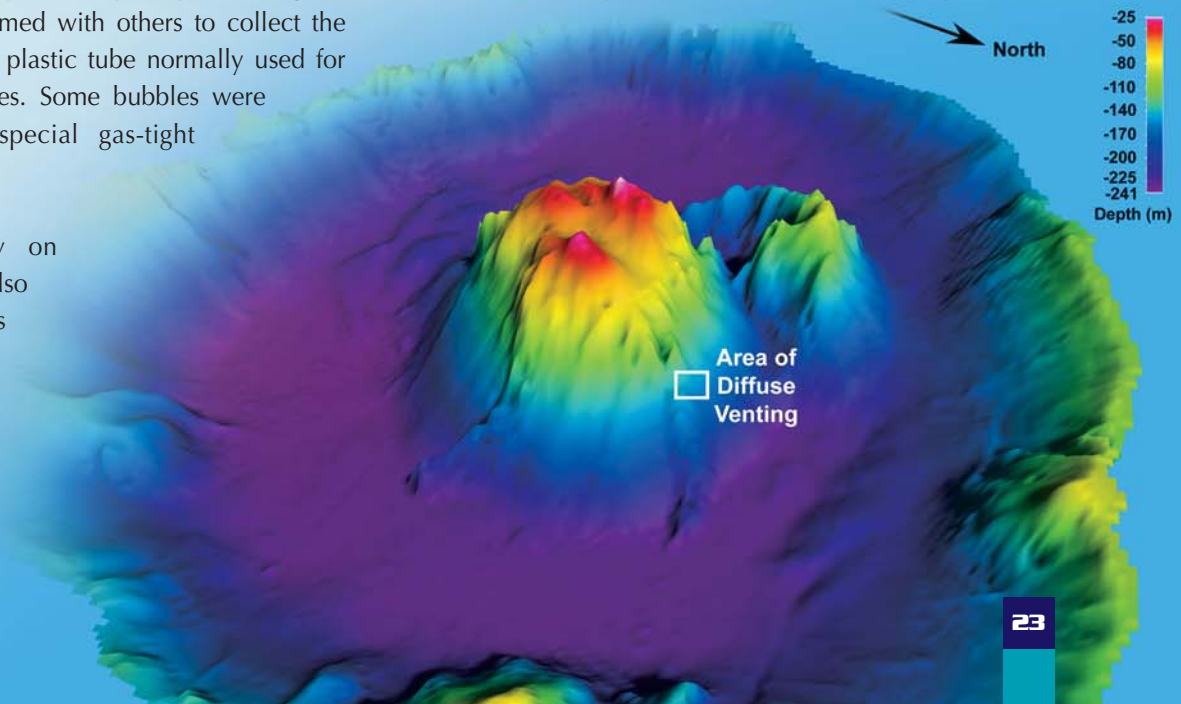
## EXPEDITION AT A GLANCE

- Submarine Ring of Fire–2004
- Submerged Volcanoes of the Mariana Arc
- March 27 – April 18, 2004
- ROV *ROPOS* and R/V *Thomas G. Thompson*
- 34 top scientists from four nations
- Made path-finding discoveries
- Obtained first video of an underwater eruption
- Observed liquid CO2 bubbles rising from seafloor
- Found rare convergence of photo-synthetic and chemosynthetic life

In some areas, the seafloor was covered with a thick reddish-orange microbial "mat" produced by such microbes. Since iron is a limiting element in the surface productivity of the ocean, the hydrothermal output of iron out of such shallow submarine volcanoes is of particular interest.

Biologists found a wealth of new discoveries at the East Diamante volcano in the Mariana Arc. Although it is thought this volcano has not erupted for many hundreds of years, there was extensive hydrothermal activity on the youngest volcanic cones in the center of a six-mile caldera. Scientists observed the rare convergence of the photosynthetic zone, where all life depends on sunlight, and the chemosynthetic zone, where energy is mostly derived from chemicals such as hydrogen sulfide released from reactions between hot seawater and volcanic rocks.

*ROPOS* climbed a slope covered with a fine white microbial mat feeding off gases from the hydrothermal activity. At 650 feet below the surface, the first photo-synthetic green and red algae appeared beneath the white bacterial growth. At 550 feet, *ROPOS* reached the top of the cone where photosynthetic life dominated. Coral and large basket stars abounded, and schools of multi-hued tropical fish swarmed around the peak. ■




# Mountains in the Sea

Five seamounts in the northern New England Seamount chain were explored during this expedition. Three seamounts that had been explored during the 2003 cruise (Bear, Manning, and Kelvin) were revisited, and Retriever Seamount was explored for the first time. A last-minute, opportunistic decision to dive on Balanus Seamount (which had not been visited in more than 30 years) led to some unexpected discoveries.

The diverse collaborative group on this 17-day cruise on NOAA ship *Ronald H. Brown* included fish biologists, geneticists, a benthic ecologist, a museum specialist from NOAA, biological oceanographers, educators, graduate students, and a specialized team to manage, maintain, and operate the ROV's, satellite dish, and other highly advanced technology.

The expedition was the first collaboration between OE and the Sea Research Foundation's Institute for Exploration (IFE), to use IFE vehicles and personnel to meet objectives not directly associated with IFE. It was also the first time science participants had nearly unlimited real-time access to the high definition images obtained by the IFE dual ROV system of *Hercules* and *Argus*. The satellite technology on board, and the IFE "Inner Space" technology on shore at the University of Rhode Island, provided opportunities for public viewing of the ROV work on the seamounts, and for live educational broadcasts.

Key objectives included documenting occurrences of corals and current flow around the seamounts, conducting in-situ observations, and collecting specimens of corals and their commensals. Relationships of benthic fishes to coral distributions and other aspects of the seamount landscapes were also documented. Coral specimens were collected and preserved for later genetic and reproductive analyses and positive identification. Larval settlement blocks deployed during a 2003 cruise were retrieved and preserved for later examination for the presence of newly settled coral larvae. This information will help determine how deep-sea coral colonies form and persist on seamounts.

Multibeam data was acquired at each seamount and during transits between dive sites. This was used with data acquired during a 2003 cruise, and data shared by a collaborator who visited the region in 2003, to develop a reasonably comprehensive multibeam data set of the northern New England Seamount chain. High-resolution topographic maps were developed from these combined data sets and were used to identify the primary target locations for ROV dives.

The expedition discovered 10 new octocoral species and collected 27 octocoral species to examine for associated invertebrates. An interesting organism found living on corals was a colorful deep-sea version of a snapping shrimp. The tiny females were found bearing eggs, living amongst branches of various elegant *chrysogorgiid* corals. "It was amazing to witness the organisms associated with the corals, as most scientists never have this opportunity," said Les Watling, chief scientist and benthic

ecologist from the University of Maine. "You can't possibly determine which organisms are associated with specific coral species by dragging a net over the bottom. You really need to observe the corals prior to collecting them."

Live corals were examined for preliminary classification, polyp morphology, polyp behavior, and reproductive state. Coral tissues were preserved for further reproductive and genetic analyses, and positive identification. Preliminary examination of coral polyps at sea showed nearly half the colonies contained eggs in various stages of development, and live sperm and developing embryos were found in several colonies. The presence of embryos in coral tissue suggests that some deep water corals may brood their young. As very little is known about reproduction in deep-water corals, a finding such as this is considered significant.

Video transect surveys obtained information on habitat features and associated organisms within seamount landscapes. Fisheries scientists on board used this data to develop a landscape classification scheme for deep sea fishes on the seamounts, to classify patterns of habitat use. ROV's spent about 157 hours on the bottom photo-documenting seamount habitats and collecting specimens. More than 470 specimens were collected, including corals, sponges, and invertebrates, and most will be deposited in the Smithsonian's National Museum of Natural History and the Peabody Museum of Natural History at Yale University.

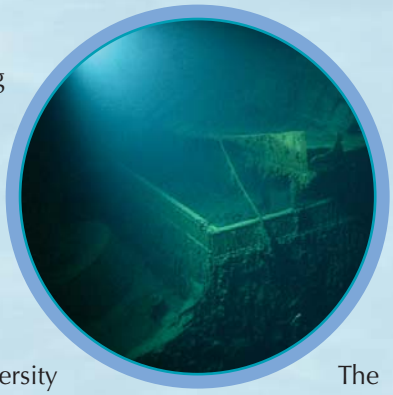
### EXPEDITION AT A GLANCE

- Five New England Seamounts studied
- May 8-24, 2004
- NOAA ship *Ronald H. Brown*
- IFE's ROVs *Argus* and *Hercules* on seafloor 157 hours
- 420 specimens obtained
- More than 10 new species of octocorals found
- Extensive acquisition of multibeam data
- Extensive education and outreach

Three lesson plans tied to the mission were developed for Grades 5-12, and teachers from throughout Alaska participated in a professional development offering. Outreach calls were made from the ship and from DSV Alvin on the seafloor, to teachers and students at UCAP, a school in Providence, RI for at-risk students; to teachers gathered at the Alaska SeaLife Center; to scientists at the Institute of Genomic Research in Rockville, Md.; and to a class of at-risk students in Indianapolis. AP and the Providence newspaper covered the call to UCAP, a newspaper reported on the Indianapolis call, and at the end of the cruise, a media availability with scientists in Astoria, Ore. resulted in extensive media coverage. "I hope the kids will see how fascinating the world is and what they can do when they are educated. The more they see beyond the boundaries of their neighborhoods, the farther they can go and they'll see possibilities instead of limitations," said Rob DeBlois, director of UCAP School.

Multibeam data showed that the Balanus site had three peaks and a dive at the base of one of the steeper peaks resulted in some of the more beautiful images of corals and sponges acquired. During the final science meeting on board to wrap-up the cruise, Watling, said, "We exceeded all our expectations. I admit I was skeptical of what the ROV's could really do, but they were just fantastic. The IFE crew was so responsive and ready to solve every problem. We've seen what's possible with this technology now, and it's very impressive." ■

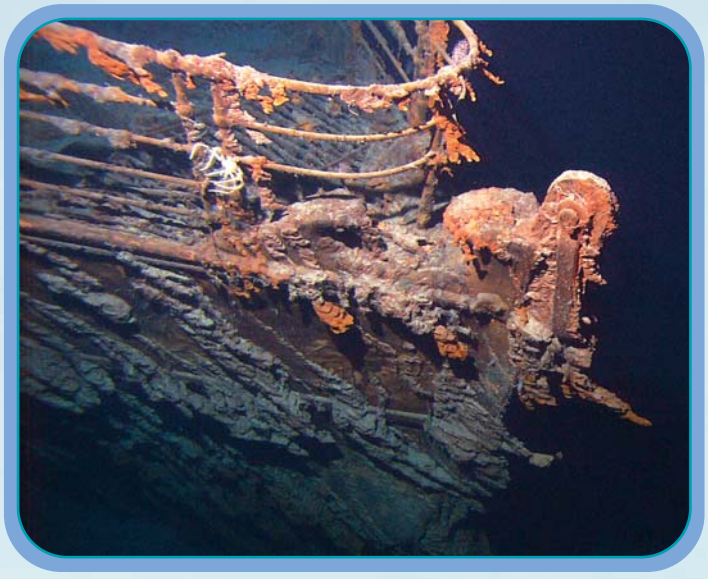

# Return to *Titanic*



Nearly 20 years after first finding the sunken remains of RMS *Titanic*, marine explorer Dr. Robert Ballard returned in June 2004 to help the National Oceanic and Atmospheric Administration (NOAA) study the ship's rapid deterioration.

A professor of oceanography at the University of Rhode Island (URI) and director of its Institute for Archaeological Oceanography, Ballard and his team of scientists from NOAA and other institutions spent 11 days at the site, mapping the ship and conducting scientific analyses of its deterioration. The mission was conducted from May 30 through June 9, from NOAA ship *Ronald H. Brown*, using the Institute for Exploration's remotely operated vehicles (ROVs) *Hercules* and *Argus*. The "look-don't-touch" mission used high-definition video and stereoscopic still images to provide an updated assessment of the wreck site.

As the nation's ocean agency, NOAA has a vested interest in the scientific and cultural aspects of the *Titanic*, and in its appropriate treatment and preservation. A focus is to build a baseline of scientific information from which to measure the shipwreck's processes and deterioration, and apply that to other deep-water shipwrecks and submerged cultural resources.



The science team included URI's Dwight Coleman, the expedition's research chief. As the marine archaeologist with NOAA's Office of Ocean Exploration, LT. Jeremy Weirich oversaw the marine archaeology component. Expedition goals included the microbial research of Droycon Bioconcepts' scientist Roy Cullimore, who studied natural deterioration of the ship's hull. Tiny microbes that feed on iron and create icicle-shaped formations called rusticles are responsible for this deterioration. While rusticles have been observed for many years, little is known about them.

The return trip to *Titanic* was not an easy one. The explorers and the crew battled weather so difficult it sometimes kept the ROVs lashed to the deck of the tossing ship. Technicians from Ballard's Institute for Exploration soon had the ROVs ready for deployment, and when "windows" of good weather appeared, the underwater robots began their four-hour dive to the remains of the great ship.

In addition to state of-the-art cameras, ROV *Hercules* was equipped with a suite of oceanographic sensors and mapping technology to document the site accurately.

"High definition still and video cameras on the underwater robots mapped the separated bow and stern sections of the ship," said Weirich. "Additional research was conducted on rusticles that hang from

the ship giving the appearance of a ship that is melting," he said. Scientists also recovered and replaced two platforms containing a variety of metal test strips that were set in the vicinity of *Titanic* in 1998. "It was important to go back to *Titanic*," said Capt. Craig Mclean, then director of NOAA's Office of Ocean Exploration. "It's a cultural icon and a maritime gravesite deserving of our respect. But it's also a deep-sea laboratory where we can study the chemical, biological and human effects on the ship's rate of deterioration and apply that knowledge to many other deepwater shipwrecks and submerged cultural resources around the world."

**EXPEDITION AT A GLANCE**

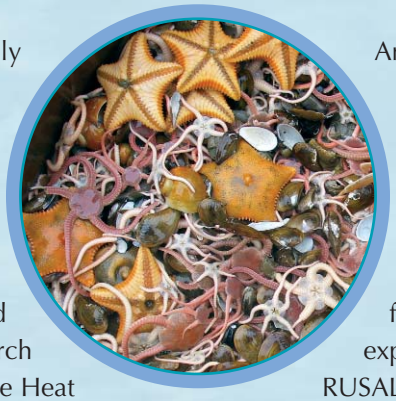
- Return to *Titanic*
- Team led by Dr. Ballard who discovered *Titanic*
- May 30 – June 9, 2004
- NOAA ship *Ronald H, Brown*
- ROVs *Argus* and *Hercules*
- *Titanic* wreck systematically mapped
- Research on microbial "rusticles," and other natural and manmade impacts on *Titanic's* deterioration
- Extensive outreach including a National Geographic Television special

One objective was to create a photo-mosaic of the ship, to compare it with photographs Ballard took of the bow section nearly 20 years earlier. "We're finding very little has happened from natural causes," said Ballard. "The ship is similar to the ship we investigated 18 years ago, except where submarines have been landing. Over the last several years," he said, "submarines came for salvage, filming and tourism, and they have been landing on the deck of the *Titanic*, doing damage."

The team planned for communications technology to play a large role in the mission. With live satellite transmissions and high-capacity Internet, mission events were beamed to scientists ashore, making them virtual members of the scientific team. In partnership with the Jason Foundation for Education and the Mystic Aquarium and Institute of Exploration's Immersion Project, thousands of students also participated. Live views of *Titanic* were part of a National Geographic Channel's "Return to *Titanic*" television program on June 7, and on World Ocean Day, June 8, Ballard and McLean participated live via satellite at the G8 Summit in Savannah.

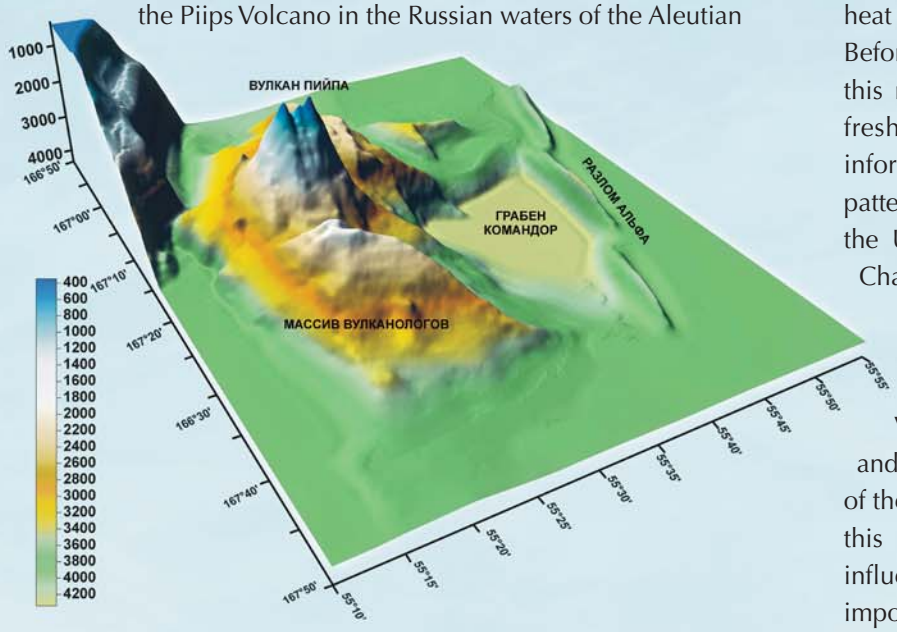
In April 2001, in accordance with the *Titanic* Maritime Memorial Act of 1986, NOAA published "Guidelines for Research, Exploration and Salvage of RMS *Titanic*." Ballard and the science team learned during the mission that the protection of *Titanic* would take a major step forward when it was announced the U.S. ambassador in London would sign an international treaty leading to enforcement authority and increased protection of the wreck site. When Congress passes enabling legislation, the agreement will enhance protection of the *Titanic* wreck site, and provide for the U.S., an extension of NOAA's 2001 guidelines. "This agreement has potential as a model for protection of other shipwrecks and submerged marine resources well beyond the territorial jurisdiction of nations," said NOAA General Counsel Jim Walpole. ■


# Russian-U.S. Arctic Census of Marine Life



The Arctic Ocean is largely unexplored. Some data collected for national defense are now available and are providing a better picture of Arctic Ocean bathymetry and circulation. The International Arctic Buoy Program provides data on ice drift trajectories and surface meteorology and there have been intensive research campaigns, such as the year-long Surface Heat Budget of the Arctic (SHEBA). Yet, there are no accurate maps of the seafloor and little understanding of currents and life in deeper portions of the Arctic Ocean, or in areas far from land-based facilities.

To explore these areas, NOAA's Arctic Research Office and Office of Ocean Exploration planned a long term program with scientists from the Russian Academy of Sciences, called RUSALCA (Russian-American Long Term Census of the Arctic). A workshop in Moscow outlined biological, geological, chemical and physical oceanographic sampling strategies in the Bering Sea, Strait and the Chukchi Sea. Primary study areas were the Piips Volcano in the Russian waters of the Aleutian Arc, and from Wrangel Island to Point Barrow north toward the Chukchi Plateau along the Herald "Canyon."




In July of 2004, the Russian research ship *Professor Khromov* sailed from Vladivostok with U.S and Russian funded scientists for 45-days of exploration and research. It was the first RUSALCA activity under a 2003 Memorandum of Understanding between NOAA and the Russian Academy of Sciences, for World Ocean and Polar Regions Studies.

The cruise went to Arctic regions shared by both countries: the Bering and Chukchi seas. These seas, and the life within, are thought to be particularly sensitive to global climate change because they are areas where steep ocean thermohaline and nutrient gradients coincide with steep thermal gradients in the atmosphere.

The Bering Strait is the only Pacific gateway into and out of the Arctic Ocean and is critical to the flux of heat between the Arctic and the rest of the world. Before establishing a climate-monitoring network in this region, scientists wanted to monitor the flux of fresh and salt water and establish benchmark information about the distribution and migration patterns of sea life. Cruise objectives also supported the U.S. interagency Study of Environmental Arctic Change (SEARCH) Program.

Waters exchanged between the Bering Sea and Pacific Ocean transit through the Aleutian Volcanic Arc where they are likely chemically and dynamically modified by hydrothermal activity of the mid-water volcanoes. Quantifying the flux from this relatively shallow volcanic arc, as well as its influence on the waters and atmosphere above, is important considering the relationship between Earth

processes—specifically, ocean and greenhouse gas exchanges.

This cruise, marked the first time Russian and U.S. scientists worked in the area, mapping volcanic features and searching for fluxes of methane and other hydrothermal fluids and gases. On the mission's first leg, scientists studied the Piips Volcano hydrothermal field, discovered by Russian marine geologists in 1987 at a depth of less than 500 meters. Researchers measured temperatures up to 130° C and discovered hydrothermal deposits of sulfates, carbonates, and amorphous silica. They detected large fields of bacterial mats and numerous hydrothermal fauna. A Russian side-looking sonar was lowered above the volcano to map the extent of thydrothermal fields below. Scientists from the Pacific Oceanological Institute in Vladivostok used hull-mounted acoustic sensors to track the rise of volcanic gas plumes. Evidence suggested the plumes vent to the atmosphere, spewing gases and even mercury into the air-sea interface. *(www.arctic.noaa.gov)*

The expedition's second leg focused on ecosystem-oriented exploration. The Arctic shows a trend in the reduction of ice cover and in the Chukchi Sea study region, there is the possibility of permanent loss of the seasonal ice cover, making the area subject to significant ecosystem change and RUSALCA studies will provide a foundation for measuring change. Nine scientific programs examined fish distribution, other water-column and benthic (sea-bottom) biological exploration, nutrient and current fluxes, methane distribution, and sea-floor processes.

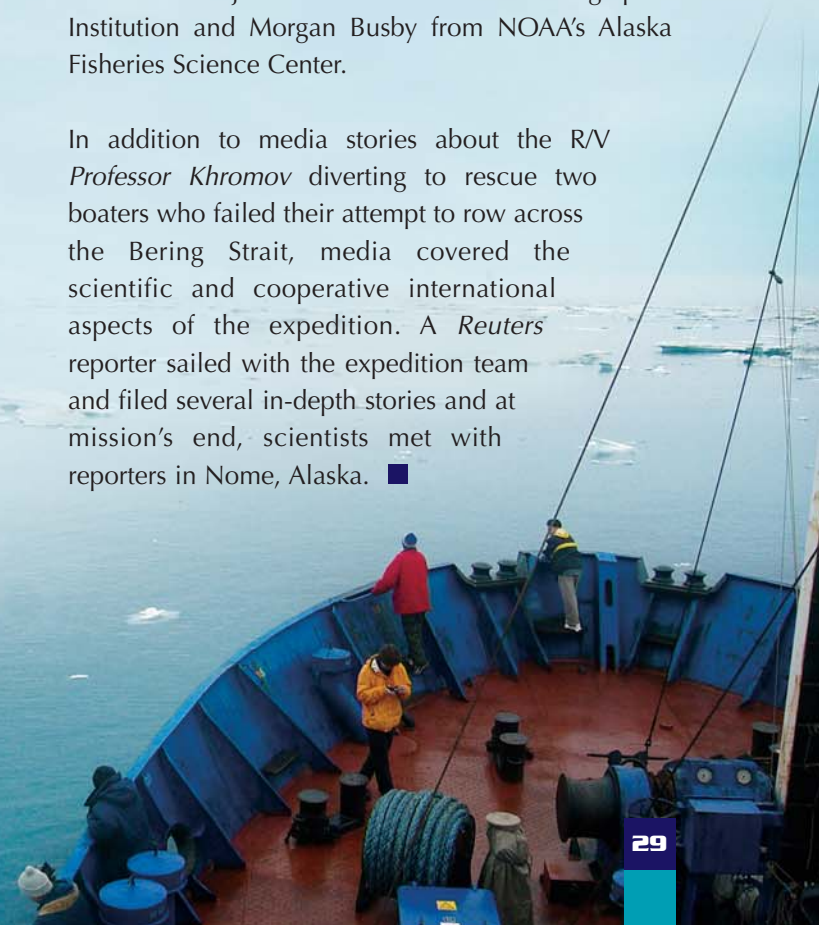
The science team used conductivity-temperature-density (CTD) stations to examine the role, rates, and rhythms of Pacific water transport through the Herald Canyon and dispersion into the greater Arctic beyond. Until recently, transport pathways of water in and out of this region have been poorly mapped. The degree these waters mix with newly invasive Atlantic waters over the Chukchi plateau and the Mendeleev and Canada basins, is not well known.

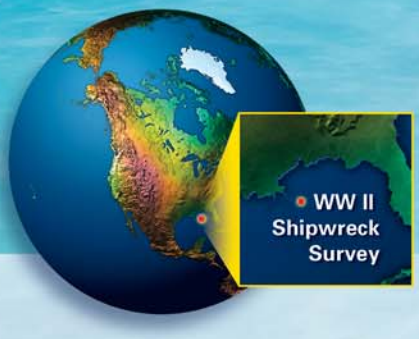
### EXPEDITION AT A GLANCE

- Collaborative U.S.-Russian Federation mission
- First mission following NOAA/Russian Academy of Sciences MOU
- Long-term Census of the Arctic
- July 23 – August 24, 2004
- Russian R/V *Professor Khromov*
- Set U.S. and Russian long-term moorings in the Bering Strait

Mission data is being coordinated with National Oceanographic Data Center, National Climate Data Center, National Geological Data Center and National Snow and Ice Data Center and with universities and other appropriate organizations. Mission Coordinators were Kathy Crane from NOAA and M. Zhdanov from Group "Alliance" in Moscow. Other scientists and coordinators included Chief U.S. Scientist Terry Whitledge from the University of Alaska at Fairbanks, Vladimir Smolin, Ministry of Defense of the Russian Federation and Russian chief of expedition, and many Russian specialists. The science team also included Russ Hopcroft and Brenda Holladay from the University of Alaska, Gillian Potter from the Smithsonian Museum of Natural History, Catherine W. Mecklenburg from the University of California at Santa Barbara, Arianne Balsom from the University of Tennessee at Knoxville, Mark Dennett and Carin Ashjian from Woods Hole Oceanographic Institution and Morgan Busby from NOAA's Alaska Fisheries Science Center.

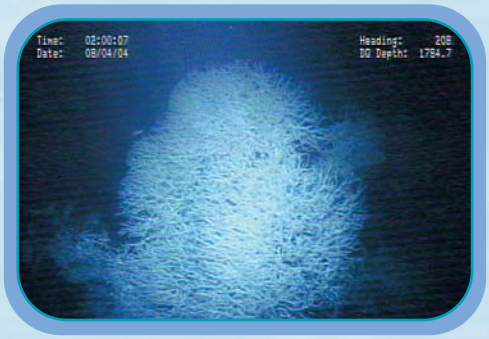
In addition to media stories about the R/V *Professor Khromov* diverting to rescue two boaters who failed their attempt to row across the Bering Strait, media covered the scientific and cooperative international aspects of the expedition. A *Reuters* reporter sailed with the expedition team and filed several in-depth stories and at mission's end, scientists met with reporters in Nome, Alaska. ■






# Gulf of Mexico Shipwreck Survey

Humans have been fascinated by the sea. In earliest times, we wondered: what creatures inhabit these deep, dark waters and what has become of the many ships that met their end at sea and now lie beneath the waves?




Today, we want to know the specifics, such as the long-term effect of manmade structures on the deep sea, and, conversely, the effect of the environment on those structures. To investigate those questions, a team of leading scientists sailed on an 18-day research mission to survey WWII Gulf of Mexico shipwrecks. NOAA's Office of Ocean Exploration (OE) supported the multi-agency mission by providing scientists and funding the ship time, a deep-submergence remotely operated vehicle (ROV), and personnel for both, all provided by Sonsub, Inc. of Houston.

The multidisciplinary group, overseen by the Interior Department's Minerals Management Service (MMS), sailed on the NOAA-contracted research and exploration vessel HOS *Dominator*. OE partnered with MMS and both operated under the interagency program called NOPP—National Oceanographic Partnership Program. A contract to conduct the research was awarded to C & C Technologies, Inc., of Lafayette, LA, which provided ship and ROV survey positioning control.

The PAST Foundation—Partnering Archaeology with Science and Technology—oversaw the study's outreach and education component. A full curriculum, based on each mission component, will be made available to educational institutions in an easy-to-download format via the PAST Foundation Web site.

C & C Technologies, a leader in the field of marine geophysical surveys, had discovered many of the wrecks included in this study. C & C was joined by a team of top scientists in the fields of microbiology, marine invertebrate and vertebrate zoology. They included Roy Cullimore of Droycon Bioconcepts, Inc. of Regina, Saskatchewan, Canada; William Schroeder, senior marine scientist at the Dauphin Island Sea Lab and University of Alabama professor; Tom Shirley, professor of invertebrate biology at the University of Alaska, Fairbanks; and William Patterson, assistant professor of marine vertebrate zoology at the University of West Florida.

The study had both an archaeological/historical objective and a biological objective. The archaeological aim was to document the wreck sites being investigated as historic properties with significance to American history. The biological component asked the question, "Do manmade structures, such as shipwrecks, function as artificial reefs in deep water?"

In the Gulf of Mexico, it is accepted that habitats are provided when decommissioned offshore oil and gas structures are converted to artificial reefs on the continental shelf. More information was needed to know if there was promise for deep-sea artificial reefs.

"The Gulf was the ideal laboratory for this study, because of the high number of steel-hulled ships that were casualties of World War II," explained Rob Church, C & C Technologies' project manager for the study. The Gulf has one of the greatest concentrations of Allied vessels lost to German U-boats, with 56 ships sunk in 1942 and early 1943.

MMS marine archaeologist Jack Irion, said "Seven of these vessels, located during oil and gas surveys required by MMS, were selected for this study because they represent a range of depths [from 280 ft to 6,800 ft] and carried a variety of cargoes. The depth range represents different ecological niches and most were sunk within a few months of one another," he said.

**EXPEDITION AT A GLANCE**

- Gulf of Mexico Shipwreck Survey
- July 29 – Aug 14, 2004
- MMS and NOAA operating under NOPP auspices
- HOS *Dominator* and SonSub's *Triton* XL ROV
- Government, Industry, University collaboration
- Biological study of the affect of the ocean environment on shipwrecks, and of shipwrecks and their cargo on the environment
- Learned that deep water shipwrecks can act as artificial reefs
- Archaeological/historical study of shipwrecks

Biologists studied the environment at each site to determine the effect each shipwreck had on the sea-floor biology, including how microbes modified sediments near and far from wreck sites, how tiny microbes cause the slow disintegration of steel structures at great depths, how the ships' cargoes might affect the rate of disintegration, and how biological communities might change as the ships deteriorate. Scientists also visited a cold seep and collected biological samples.

Team members also studied the historic merits of vessels for potential nomination to the National Register of Historic Places. "One of the most unexpected things found archaeologically was a large debris field 1,200 feet north of the wreck of *Alcoa Puritan* and a 105mm shell casing a couple of hundred feet south the main wreckage," said Church. These discoveries helped retrace the final moments of the attack as U-507 slowly overtook the *Alcoa Puritan*, crippling it with its 105mm deck gun and finishing off the freighter with a torpedo on the starboard side.

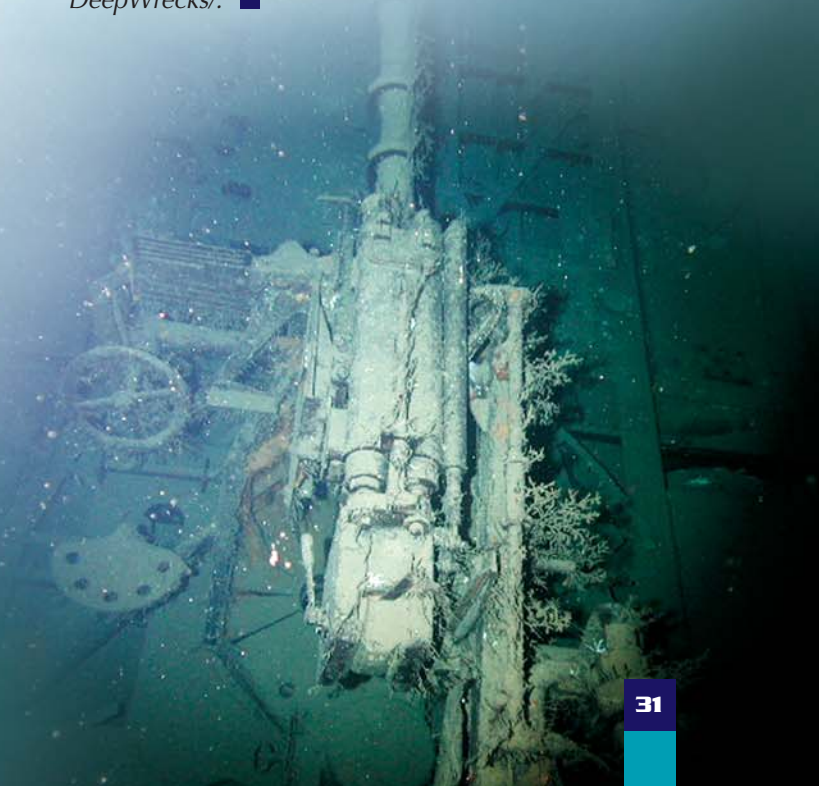
As the ROV approached the sunken tanker *Gulfpenn*, large white silhouettes appeared. Pilot Phil Spearman maneuvered the ROV closer and focused the video camera on a spectacular colony of branching deep-water coral. A collective "wow" resonated through the ROV control van. More large coral colonies were sighted, evidence of deep-sea artificial reef effects.

The team studied the sunken *U-166* to assess its condition and they examined microbiology test platforms deployed in October 2003. Vertebrate (fish) and invertebrate (crabs, etc.) traps were placed out from the wreck. *U-166* lies on the bottom not far from its last victim, the passenger freighter *Robert E. Lee*.

Mike Overfield, the coordinator for Resources and UnderSea Threats (RUST) database of NOAA's National Marine Sanctuaries Resource Protection Team, added data to an inventory of undersea threats and potential environmental hazards within United States waters.

When Tropical Storm Bonnie and Hurricane Charley came toward the end of the mission, they adjusted operations out of the track of the storm and met every objective but one—at a site directly in the path of Bonnie.

For more information about the expedition, the scientists and explorers involved and for stories of the sunken ships, visit *www.pastfoundation.org/DeepWrecks/.* ■



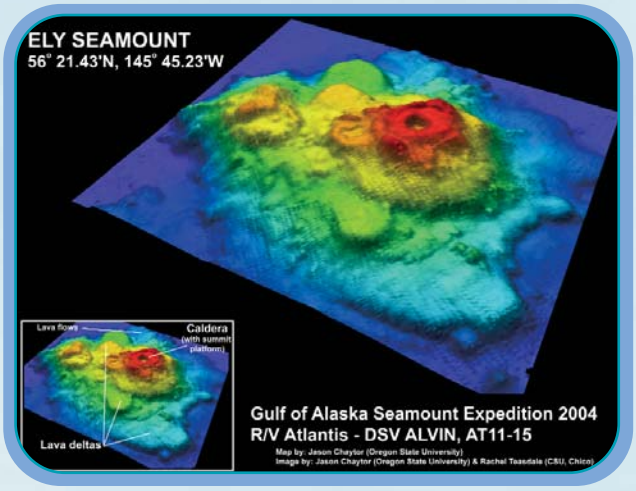

# Gulf of Alaska Seamounts

Five seamounts in the Gulf of Alaska (GOA) were sampled and photo-documented on this mission, adding to only six GOA seamounts previously explored—five during the OE expedition in 2002 and one earlier in 2004 by two Principal Investigators (PIs) from this expedition.

Isolated seamounts are known for high levels of speciation. A large percentage of seamount fauna is endemic, so potential to discover new life forms and ecological relationships is high. GOA seamounts explored so far have proven to have high biological richness, and so the results of this expedition could potentially aid in the wise stewardship of seamount resources and fauna in the GOA. Other objectives include gaining a better understanding of the geologic history of the GOA, adding to knowledge of historic climate and oceanic conditions in this dynamic region, and helping determine the importance of seamounts as essential habitats for unique and endemic species.

Good weather and a hard-working crew on the Woods Hole Oceanographic Institution's (WHOI) research vessel *Atlantis* allowed the science team to make 17 of 18 planned dives in the Deep Submergence Vehicle (DSV) *Alvin*. The five seamounts explored in the Kodiak-Bowie Seamount Chain, were Giacomini, Pratt, Welker, Denson, and Dickens, stretching over 400-nautical-miles of the northeast Pacific.

In *Alvin*, scientists dove more than 3,500 meters for biological and geological investigations of these ancient volcanoes. PIs and many others on this cruise were on the GOA Expedition in 2002.




Objectives included geologic dating and characterization of seamounts; microbiological studies of rocks; deep-sea coral distribution and genetics; community ecology of deep-sea corals; and investigation of microbial, invertebrate, and fish communities associated with the corals. Also, sponge communities were examined, and the genomics of bacteria associated with corals and their inhabitants was investigated. Coral specimens were preserved for taxonomic identification by the Smithsonian's National Museum of Natural History, and for genetic or reproductive studies.

A large number and diversity of coral, sponge, and invertebrate samples were collected, including some species new to science. Rocks were collected to determine geologic histories of the seamounts and full-coverage bathymetric maps were made of seamounts, including one documented previously only with satellite data. During investigation of seamounts and transits, multi-beam data was acquired for an area of 23081 $km^2$.

For genomic studies of bacterial communities, scientists collected 62 coral specimens, 13 sponge specimens, and 36 water samples. In addition, 300 invertebrate specimens, 140 coral specimens, and 34 sponge specimens were collected. Rock samples were collected for geologic studies and for microbial studies.

Using (DSV) *Alvin*, scientists collected samples and conducted video transects to develop a photographic

inventory of fauna including the coral, *Siphonogorgia* sp., from the family *Nidaliidae*. Amy Baco-Taylor, a co-PI from WHOI, said there were multiple individuals of this species in a small area of Pratt seamount, but this was the only species documentation during the mission. This sighting might represent range extension and may be a new species.

**EXPEDITION AT A GLANCE**

- Gulf of Alaska Seamounts
- WHOI R/V *Atlantis* and DSV *Alvin*
- July 30 – August 24, 2004
- Four funded PI's and one invited industry group (TIGR)
- 17 Alvin dives, with 76 hours bottom time
- Multibeam data acquired for an area of 23081 $km^2$
- At least 4 new coral species and 2 new sponge species discovered
- Northern range extension for one coral species and "gumdrop jelly"

Bioluminescent properties were found in a coral species previously unknown to phosphoresce and a previously undescribed *Galatheid* crab was collected. A snail fish, family *Liparidae*, was collected with DSV *Alvin's* suction gun. Shortspine thornyhead and grenadier fish were common. Both feed on small crustaceans such as shrimp living on sponges 2,000 ft deep. One community of shrimp seemed to be fighting for position around a small rock that somehow landed on a glass sponge—one of a half-dozen species of glass sponge NOAA scientist G. P. Schmahl documented.

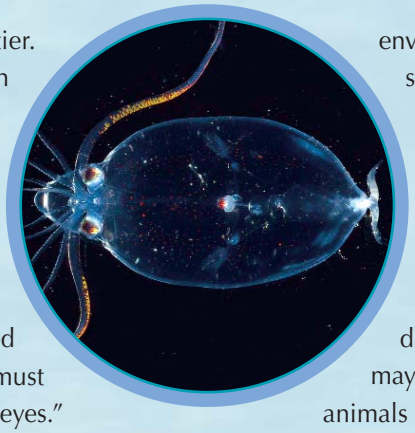
"Deep-sea corals are often considered the 'condominiums of the deep,' because they provide habitat for a large variety of organisms," stated Tom Shirley, chief scientist and University of Alaska scientist during the cruise.

Scientists discovered a significant northern range extension for mesopelagic *Scyphomedusa* commonly called "big red" or the "gumdrop jelly." This new species was originally described in 2003 and during this mission the enormous and beautiful gumdrop jelly was observed on three of the five seamounts explored. Shirley has a manuscript in progress related to this discovery.

Co-PI and Assistant Professor at Oregon State, Randy Keller researched volcanic rock formations, including those with a round, blobby appearance somewhat like "pillows." "This only occurs underwater," he said. Naomi Ward from TIGR collected bacteria from deep-sea corals for DNA sequencing. "There is more microbial mass on Earth than the biomass of all other life forms put together," she said.

Education and outreach were extensive, and brought the excitement of discovery to several groups of students and teachers through satellite phone calls patched down to the *Alvin* sub at depth. Background information and cruise activities were shared with the public through NOAA's Ocean Explorer Web site, and near-daily logs included still and video images from the *Alvin* dives. An educator from an alternative school in Providence, RI, a MATE Intern, and a Sea Grant Knauss Fellow were part of the at-sea team. Teachers ashore accessed mission-specific lesson plans and a Professional Development Institute was held at the Alaska SeaLife Center. Media and educators toured the ship and spoke with scientists and crew when the cruise ended in Astoria, OR on August 24. ■


# Operation Deep Scope



The deep sea is a dark frontier. Attempts to shed light on mysteries at the ocean's depths have been clouded at best. How many marine animals have swum out of our nets, evaded our bright and noisy submersibles or simply escaped our notice? To discover these creatures, and learn more about how they have adapted to life in the ocean darkness, we must explore in new ways and see with "new eyes."

Funded by NOAA OE, Operation Deep Scope sailed aboard Harbor Branch Oceanographic Institution's (HBOI) R/V *Seward Johnson II*, and featured use of new and one-of-a-kind equipment. The science team included international experts in optical oceanography and visual ecology. Innovative and advanced camera systems made it easier to see animals under extremely dim light, without disturbing them. Scientists also deployed newly designed light-tight traps in hopes of bringing new deep-sea to the surface, alive and with their remarkable eyes intact.

This exploration to the northern Gulf of Mexico was in a geologically complex region. With basins, canyons, escarpments, and seeps, this region is better suited to exploration by submersible than by traditional sampling with nets and trawls. It's an area of intense biological interest, after the recent discovery of rich communities of tubeworms, associated predators, and other organisms, whose food web is based on chemicals from methane seeps.

Deep Scope scientists explored life up to 3,000 feet deep at four sites, measuring and characterizing light from the sun and from bioluminescence in these ecosystems. Light has been described as the most powerful selective force in evolutionary history. Understanding how animals adapted to light in their environments—to see and be seen (or not be seen)—will provide insight into the nature of life in these unusual communities.

Sampling with nets and brief visits with submersibles and remotely operated vehicles (ROVs) have significant limitations. Bottom trawling nets can damage animals and destroy habitats, and may grossly underestimate the number of animals present. Submersibles and ROVs use noisy thrusters and bright lights that undoubtedly frighten off animals and certainly disturb their behaviors. Advances in underwater imaging and optical system design opened an exciting new frontier for ocean exploration. The mission's main goal was set forth at the 2000 President's Panel for Ocean Exploration: to "see the oceans through a new set of technological 'eyes.'"

Another aspect of the mission targeted dive sites in a region of escalating gas and oil exploitation. These studies will provide a better understanding of associated rich biological communities, which is essential for their proper management and protection.

Edie Widder, senior scientist at and director of HBOI's Bioluminescence Department, co-led the team. She made the first video recordings of ocean bioluminescence, developed both *Eye-in-the-Sea*, a deep-sea observatory to record bioluminescence behaviors, and another system now the standard in the U.S. Navy for measuring bioluminescence.

Co-leader Tamara Frank, head of HBOI's Visual Ecology Department, addressed the challenge of getting animals to the surface without lights damaging their eyes. Frank used light-tight, baited traps, designed by HBOI's Engineering Division. Preliminary findings showed that crabs collected in light-tight traps still had extremely

sensitive eyes, but those collected under the bright submersible lights and brought to the surface in transparent containers, were completely blinded.

Dive locations included a spectacular deepwater coral reef known as Viosca Knoll, methane seeps where chemosynthetic clams and worms rely on methane-eating bacteria for nutrition, and the Brine Pool, a bizarre site where salt deposits from beneath the seafloor dissolve to create water so dense it forms a shallow lake 2,100 feet below the ocean's surface.

The value of the new camera was seen in compelling deep-sea predator footage, and data to support a new theory about how some animals may use polarized light to find prey. Footage showed many animals including a 12-foot sixgill shark, and a six-foot squid that could be a new species. "Knowing something like that could be discovered in such a short time, it's difficult not to conclude that countless strange, beautiful, and important discoveries still await us in the depths," said Widder.

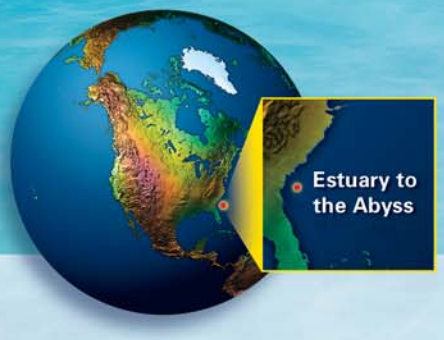
The camera system uses new technology and very low levels of red light that deep-sea animals can't see, to image animals and behaviors scientists might otherwise never observe. An electronic jellyfish lure to mimic bioluminescent displays by deep-sea animals, appears in some clips to have attracted animals, suggesting the system could be important for studying bioluminescence uses in the deep sea.

Charles Mazel, of Physical Sciences, Inc., discovered the world's first known fluorescent shark using special blue filters on the submersible's lights. And Mike Matz, from the University of Florida, unexpectedly discovered that methane hydrates are brilliantly fluorescent. Methane hydrates, ice crystals that trap fossil fuel methane, are a potential energy source and knowledge they fluoresce could lead to new detection techniques. Widder discovered a bioluminescent anemone not previously known to produce light and she found that Venus flytrap anemones produce a bioluminescent slime, though its use is not clear. The team collected fluorescent crabs, corals, anemones, and fish they will study for fluorescent proteins that might benefit genomic and other biotechnology research.

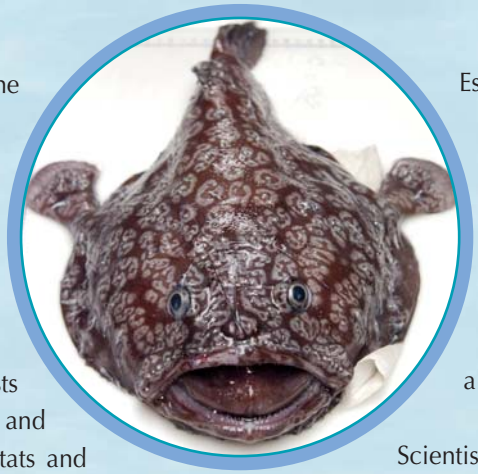
"This has been exploration in its purest form, something that is all too rare," said Widder. "To say this cruise was a success would be an understatement. We are returning with an embarrassment of riches." ■

### EXPEDITION AT A GLANCE

- Operation Deep Scope
- Northern Gulf of Mexico
- Explored deep sea life and use and effects of light
- August 7-17, 2004
- R/V *Seward Johnson II*
- Johnson-Sea-Link (JSL) I, manned submersible
- International Science Team
- "Eye-in-the-Sea" Camera Proof-of-Concept
- First known species of fluorescent shark
- Fluorescence from methane hydrates seen




# Estuary to the Abyss



The "South Atlantic Bight" is the continental shelf off the southeastern U.S. It stretches from Cape Hatteras and Diamond Shoals off North Carolina, past the cuspate coastline and broad shelf of the Carolinas and Georgia, and down to the Gulf Stream north of the narrow Florida Straits at Cape Canaveral. Fishery scientists and marine ecologists have researched and monitored the shelf and nearshore habitats and have closely studied the interaction of productive coastal waters and associated marine life on the bottom.

Offshore waters of the region were relatively unexplored until the second half of the twentieth century, when vessels of the U.S. Bureau of Commercial Fisheries (a predecessor to NOAA) began exploratory commercial fishing in the 1960s. Interests in petroleum exploration in the 1970s led to additional studies aimed at further describing habitats and assemblages of algae, invertebrates, and fishes associated with hard- or live-bottom reefs of the continental shelf.

NOAA's National Marine Fisheries Service and the South Carolina Department of Natural Resources (SCNDR) monitor fish populations and NOAA's Center for Coastal Environmental Health and Biomolecular Research conducted additional research and monitoring on invertebrate communities. The area is home to one of the 13 National Marine Sanctuaries, Gray's Reef, that continues to be a focus of coral reef research. Previous research has concentrated on shallow, productive coastal waters and coral reefs of the continental shelf. Recent NOAA expeditions and other research in the region have focused on the Charleston Bump, a bottom feature that influences the flow of the Gulf Stream, enhances productivity, and is an important fishing ground. Areas of the ocean offshore of the Charleston Bump, however, are virtually unexplored.

Estuary to the Abyss expanded on existing sampling and surveys conducted along the Latitude 31-30 Transect, by extending the transect down onto the continental slope and the Blake Plateau, exploring the diverse habitats and species assemblages along the deep end of the transect.

Scientists collected data to examine the effects of habitat, management, terrestrial runoff, oceanographic features, and physical gradients on faunal assemblages, ranging from bacteria to fishes. One goal was to determine faunal change and human impact along a gradient of increasing depth and increasing distance from land, combined with variable hydrography and bottom complexity. The science team used submersibles, dredges, nets, and associated oceanographic and photo-documentation gear to describe diverse habitats, features, oceanography, and faunal assemblages. They mapped bottom features with sonar, explored unique habitats, observed and sampled faunal changes along a transect in depths between 500-2,000 meters, collected new and unusual species and samples of deep-water non-migratory fishes to examine impacts of antimicrobial resistance in the marine realm.

Using a research submersible, small dredges and trawls, and plankton nets, scientists collected corals, mollusks, decapods, and other organisms to elucidate patterns of recruitment and growth. Bacteria cultures were obtained from deep-ocean non-migratory fishes, and shipped to Louisiana State University where investigators at the School of Veterinary Medicine will look for the presence of antimicrobial resistant organisms.

Based on historical bottom-sounding maps and the ship's sonar, 20 dive sites were selected as likely to have diverse habitats and organisms. At one point, the

submersible's operators controlled the mechanical arm to pick up one of the most unusual fishes many of the scientists had ever seen. Byron White, a marine biologist at the SCDNR Marine Resources Research Institute, identified it as a *Sladenia shaefersi* or "Shaefer's anglerfish," and scientists named the specimen, "Bubba." Only two specimens were previously seen, one off the coast of Colombia in 1976 and the other later near Aruba. This third sighting was far north of its known range. Geographic range was also extended for the mollusk, (*Bayerotrochus midas*).

### EXPEDITION AT A GLANCE

- Estuary to the Abyss
- Exploring deeper waters on Latitude 31-30
- Observing faunal changes along the transect
- August 20 – September 1, 2004
- R/V *Seward Johnson II*
- Johnson-Sea-Link (JSL) II, manned submersible
- 13 JSL dives/more than 30 hours bottom time
- Deep-sea non-migratory fishes studied for anti bacterial resistance
- Corals and mollusks to be analyzed for age and climate history

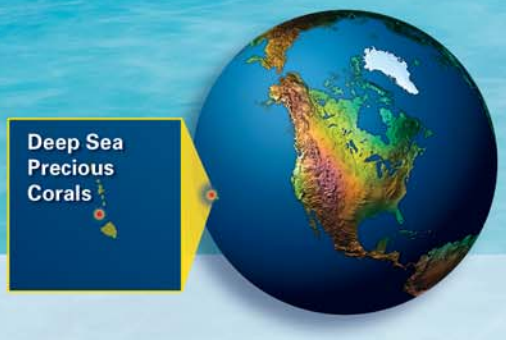
While watching video of another dive, scientists identified a frilled shark (*Chlamydoselachus anguineus*). Though the species has been caught in nets, it's believed this was the first time this rare species was seen in its natural habitat.

Rock and sediment samples were collected and samples of corals and mollusks were obtained to determine age and climatic history. Scientists are interested in dead coral samples because like trees, they have growth rings that could tell stories about past climate over decades, or even centuries. These observations could prove useful in forecasting climate in the area.

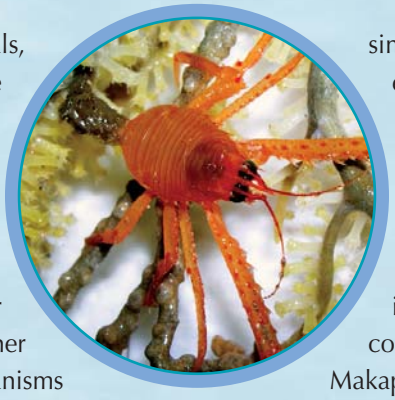
The expedition team was led by Principal Investigator George Sedberry from the Marine Research Institute at South Carolina Department of Natural Resources (SCDNR), and included scientists expert in ichthyology, fisheries biology, geology, invertebrate systematics/taxonomy, marine geology, engineering, data management, formal and informal education, benthic ecology, reef biology, deep-sea biology and geography. Five graduate students on the cruise corresponded with high school and undergraduate students and two educators-at-sea were involved in all activities, and corresponded with secondary and college marine biology and marine geology classes.

Partners in the expedition included NOAA OE, NOS, NCCOS, NCDDC and Fisheries; SCDNR; South Carolina Aquarium; and College of Charleston.

"By extending sampling to waters between 1,800 and 3,000 meters deep, we collected and observed several rare and poorly known fishes and other organisms," remarked Sedberry. "But more exploration is needed to expand this transect out onto the edge of the Blake Plateau and beyond. The Blake Scarp, Blake Ridge, and Blake Spur are poorly known, but bathymetry maps indicate they are areas with complex bottom topography in much greater depths than sampled previously," he said. "Future explorations should examine these fascinating deepwater habitats, which show promise for harboring rare, unusual new species. Every dive, observation or collection from the deep sea off the southeastern U.S. brings new or unusual species and additional knowledge of the sea just beyond our shores." ■




# Deep Sea Precious Corals



When diving on deep-sea corals, it is hard not to notice the many invertebrates that are associated with the corals. Deep-sea gorgonian corals provide habitat for many other creatures because corals add habitat complexity, altering the seafloor by adding a large structure for other organisms to climb up on to reach higher into the water column. Many of these organisms are also suspension feeders, like the corals. The higher up they rise into the water column, the more food they will find. We find many invertebrates living on corals, including brittle stars, basket stars, crinoids (sea lilies), polychaetes, galathaeid crabs, and sponges.

Few studies have focused specifically on the assemblages associated with deep-sea coral species. Submersible observations of precious corals and other gorgonians found in the precious corals beds on several islands and seamounts in the Hawaiian Archipelago have shown that a number of species may inhabit a single coral tree. Additionally, it appears that each species of coral consistently harbors different characteristic species. Despite these observations, none of these fauna have been quantified, and few have been identified. On this cruise, scientists examined coral-associated invertebrate fauna at three large precious coral beds in the Hawaiian Archipelago, the Makapu'u Bed, on the southeast slope of Oahu, the Keahole Bed, on the western slope of Hawaii, and the Cross Seamount Bed. The most abundant coral species in these three beds are the pink coral, *Corallium secundum*, the red coral *Corallium regale*, and the gold coral *Gerardia sp.* These species are concentrated at depths of 300-500 meters.

Investigators included Drs. Amy Baco-Taylor and Timothy Shank from Woods Hole Oceanographic Institution, and Thomas Shirley from University of Alaska, Fairbanks. Graduate students from the University were also part of the science team and collected and identified coral-associated invertebrates to use for species identification and to determine community structure. They also sought to compare the lists of invertebrate species associated with each coral species to determine if certain invertebrates prefer to live on certain species of corals.

The team operated from the the Hawaii Undersea Research Laboratory's (HURL's) Research Vessel *Ka'imikai-O-Kanaloa*, and used the manned submersible *Pisces V* and the remotely operated vehicle RCV-150. HURL was established by the University of Hawaii and NOAA's National Undersea Research Program (NURP), and is one of six NURP centers.

The mission was a successful one. A total of 185 coral specimens were collected and identified from eight dives made on three precious coral beds. All the coral specimens or the appropriate pieces collected on the cruise were sent to museums for curation and taxonomy. Specimen donations were made to the Smithsonian Institution and the California Academy of Sciences. Providing specimens to museums allows for additional outreach to the public and benefits the scientific community because it makes the specimens available for species descriptions, for museum displays and for comparisons to future collections.

"All of the coral beds had a very diverse assemblage of both precious and non-precious corals," said Baco-Taylor. "Precious corals are used to make jewelry and they used to be collected using tangle nets. We found an old tangle net at Makapuu where the heavy bar and chains were used to break up the corals and a net was attached to the chains to collect all the pieces," she said. "As you can imagine, this was very destructive to the coral beds."

### EXPEDITION AT A GLANCE

- Deep Sea Precious Corals
- Hawaiian Islands and Seamounts
- Investigators Amy Baco-Taylor and Timothy Shank from Woods Hole Oceanographic Institution, and Thomas Shirley, University of Alaska, Fairbanks
- October 2-18, 2004
- HURL R/V *Ka'imikai-O-Kanaloa*
- Manned submersible *Pisces V*, 8 dives
- RCV-150, 12 dives
- At least three new species discovered

Faunal assemblages on the corals included species from 13 different phyla and a large number of lesser taxa. Some of these species may represent range extensions.

Additional invertebrate identifications are being completed primarily by Tom Shirley and his students. Anemone specimens have been donated to Daphne Fautin, at the Natural History Museum in Kansas, who will provide identifications. Dr. Emilio Garcia, Professor Emeritus, ULL, is assisting with identification of selected gastropods.

Dr. Stephen Cairns from the Smithsonian Institute provided species identification for all octocorals collected on the cruise, which included at least three new species. Dr. Dennis Opresko has begun identifying the Antipatharians collected.

Additionally, Dr. Les Watling of Darling Marine Laboratory will add the Chrysogorgiids collected on this cruise to his studies revising the taxonomy of this family. ■

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# PHOTO CREDITS

**Inside front cover** – Stunning yellow Enallopsammia stony coral with pink Candidella teeming with brittle stars. Photo courtesy of the Mountains in the Sea Research Team; the IFE Crew; and NOAA.

**Page 4** – Top right photo: Beautiful bouquet of Lophelia, Candidella, and solitary cup corals with brittle stars, crinoids, and various sponges. Photo courtesy of the Mountains in the Sea Research Team; the IFE Crew; and NOAA. Middle left photo: A small sea urchin brought to the surface by the *Johnson Sea Link II*. Middle right photo: An arcturid isopod clings to a branch of an octocoral. This photo was taken using a camera mounted to a microscope. The field of view of the photo is 3 millimeters. Bottom photo: This polycheate worm gathered in the first box core was almost 7 cm in length. Some of the scientists believe the white spots visible in the body are eggs. Photo courtesy Casey Debenham.

**Page 5** – Scientists on the 2004 Gulf of Alaska Seamount expedition crowd around the bio boxes at the front of the Deep Submergence Vehicle *Alvin*, eager to see what was collected during that day's dive. Photo courtesy Jeff Pollack.

**Page 8** – Top photo: USS 0-9. Photo courtesy U.S. Naval Institute. Bottom photo: Artist's rendition of USS 0-9 before its sinking. Image courtesy NOAA's Rick Yorczyk.

**Page 9** – Great Lakes shipwrecks. Photos courtesy Thunder Bay National Marine Sanctuary.

**Page 10** – Ranges and depths of marine animals were charted in earlier NOAA-sponsored projects for a Census of Marine Life. Images courtesy NOAA and Oregon State University.

**Page 11** – Bouquet of Corallium with deep purple Trachythela octocoral, brittle stars, crinoids, and sponges. Photo courtesy of the Mountains in the Sea Research Team; the IFE Crew; and NOAA.

**Page 12** – Top right photo: Corals can also grow on other corals. Here we see a colony of the primnoid *Callogorgia* with *Gerardia sp.* growing over it. An unbranched basket star in the genus *Asteroschema* has also made its home on this colony. Photo courtesy Amy Baco-Taylor; Thomas Shirley; pilots T. Kerby and M. Cremer; and NOAA. Bottom left photo: a small Acanthogorgiid coral being collected by the *Pisces V* manipulator. You can see 2 anemones in the lower left of the colony and the claw of a chirostylid crab. Photo courtesy Amy Baco-Taylor; Thomas Shirley; pilots T. Kerby and M. Cremer; and NOAA.

**Page 13** – The orange gas hydrate is home to *Hesiocaeca methanicola*, a newly discovered species of marine worm found in the Gulf of Mexico in 1997. This lobe of hydrate was exposed on the seafloor. The Deep East Expedition will investigate the life above and in a shallow bed on the Blake Ridge where other lobes of exposed gas hydrates are believed to be located. NOAA photo.

**Page 14** – Robotic arms gather samples from the ocean floor. Photo courtesy URI/IFE and the Mountains in the Sea expedition team.

**Page 15** – Top left photo: After conversion in a shipyard, the former Navy ship USNS *Capable* will become NOAA's only ship dedicated to exploring unknown or little known ocean areas. Photo courtesy U.S. Navy. Bottom right photo: *Hercules* ROV. Photo courtesy IFE.

**Page 16** – Students from Porter Gaud school in Charleston visit NOAA ship *Ronald H. Brown*. NOAA photo.

**Page 17** – Teachers in action at a NOAA-sponsored Professional Development Institute use lesson plans from NOAA's Learning Ocean Science Through Ocean Exploration. NOAA photo and images.

**Page 18** – Top left photo: Outreach extended from NOAA ship *Ronald H. Brown* at sea to a satellite-connected press conference in Savannah as part of the Sea Island G-8 Summit. NOAA's Ben Sherman takes an audience question for Dr. Robert Ballard and NOAA Capt. Craig McLean who were on the ship 12,000 feet above the wreck of RMS *Titanic*, on a NOAA-sponsored "Return to *Titanic*" mission. NOAA photo. Bottom right photo: Students at UCAP school in Providence, R.I. talk by satellite phone with NOAA scientist and former UCAP employee Catalina Martinez while she is in a submersible more than 8,000 feet deep in the Gulf of Alaska. NOAA photo.

**Page 19** – Top right photo: Ocean Hall planning meeting. NOAA photo. Bottom left photo: Artist's rendition for Ocean Hall. Image courtesy Smithsonian Institution.

**Page 22** – Top photo: Unusual spiny crab spotted on NW Rota 1 volcano. Crabs are opportunistic predators at vent sites. The body of this crab is ~2 in. (~5 cm) across. NOAA photo. Bottom photo: White chimneys at Champagne vent site, NW Eifuku volcano. The chimneys are ~20 cm (8 in) across and ~50 cm (20 in) high, venting fluids at 103ºC (217ºF). Notice the bubbles in the upper left portion of the image. NOAA photo.

**Page 23** – Three-dimensional view of the Maug caldera (2 times vertical exaggeration). EM300 bathymetry data (10 meter grid cell size), ranging in depth from 241 to 25 m (790-82 ft). On this 2004 Submarine Ring of Fire expedition, the Maug survey was completed, providing complete coverage over the shallow central lava dome. NOAA image.

**Page 24** – Lovely spiraling Iridigorgia coral with brightly colored (apparent) commensal shrimp. Photo courtesy Mountains in the Sea Research Team; the IFE Crew; and NOAA.

**Page 25** – A crab strikes an aggressive pose to protect this oasis of spectacular diversity. Photo courtesy the Mountains in the Sea Research Team; the IFE Crew; and NOAA.

**Page 26** – Top photo: ROV light on *Titanic's* deck. Photo courtesy IFE/URI/NOAA. Bottom photo: Rusticle-covered bow of *Titanic*. Photo courtesy IFE/URI/NOAA.

**Page 27** – The Institute for Exploration's remotely operated vehicle (ROV), *Hercules*, investigates boxes on the stern of *Titanic* during the 2004 expedition to the wreck site. Photo courtesy IFE/URI/NOAA.

**Page 28** – Top photo: A robust sample of benthic marine life. Photo courtesy Bodil Bluhm. Bottom photo: Sonar images of the Piips volcano, investigated during the first leg of the RUSALCA Arctic expedition. Image courtesy V. Gladish from VNIIOkeangeologia, St. Petersburg.

**Page 29** – The Russian R/V *Professor Khromov* sails to the next science station. Photo courtesy U.S.-Russian science team.

**Page 30** – Mission scientists and explorers found that shipwrecks deep in the Gulf of Mexico supported life, including "forests" of coral as seen here on the wreck of the Gulf Penn. Photo courtesy of expedition team.

**Page 31** – A 37 mm deck gun on the wreck of the German submarine U-166, sunk in the Gulf of Mexico. Photo courtesy C & C Technologies.

**Page 32** – Top photo: DSV *Alvin* and WHOI R/V *Atlantis*, swimmers Bruce Strickrott and Sean McPeak (Chief Alvin Pilot and Alvin Electronics Technician, respectively) working the recovery. Photo courtesy Jeff Pollack. Bottom photo: Multibeam image of Ely Seamount, showing a deep caldera and lava flows. Image courtesy Jason Chaytor and Rachel Teasdale.

**Page 33** – Large primnoid coral loaded with brittle stars on Dickens Seamount. Photo courtesy NOAA, WHOI, the *Alvin* group, and the 2004 Gulf of Alaska Seamount Expedition science party.

**Page 34** – This Caranchid squid, about four-inches across, uses transparency to hide from potential predators. Open-water divers can more easily observe these creatures with polarizing filters. Photo courtesy Edie Widder.

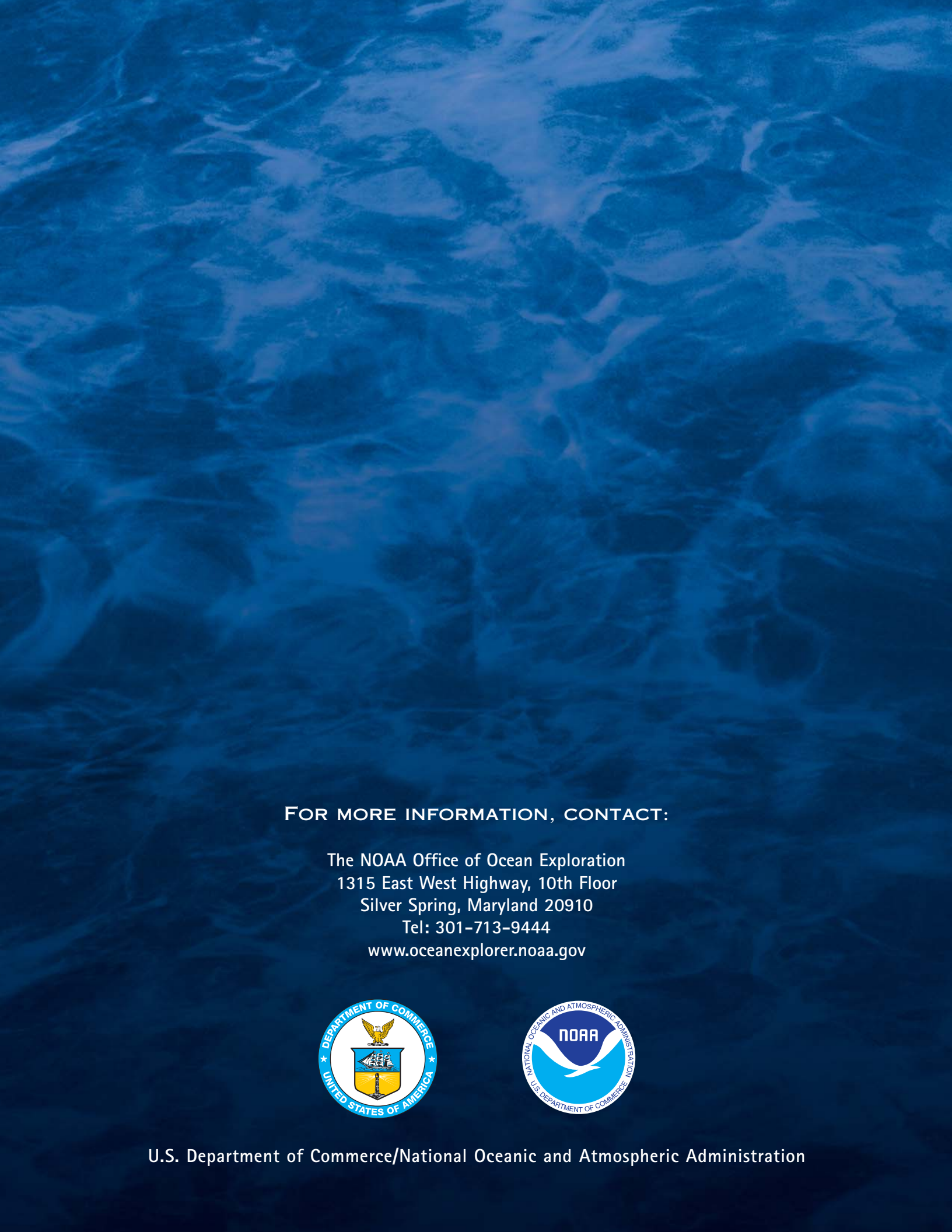
**Page 35** – Note the green fluorescence of the eyes of this short-nose greeneye fish. The submersible team collected the specimen for optical studies in the ship's onboard laboratory. Under white light, the green lenses of this six-inch greeneye fish are still quite apparent. Photo courtesy Edie Widder.

**Page 36** – Once on board ship, "Bubba" was measured, weighed, studied, and preserved. A sample of his bacteria was also taken for Mark Mitchell's antimicrobial study. The "fishing poles" on his head are illiceum, or the first and second spines of the dorsal fin. These attract prey, which swim just above his huge mouth. He then sucks the prey in. Note the centimeter scale markings on the white table. Photo courtesy SCDNR.

**Page 37** – A transparent squid that hovered near the *Johnson-Sea-Link II* submersible at the Sandy Tongue dive site today. We did not attempt to collect this cephalopod, because it was too delicate for the sub's suction sampling mechanism. Photo courtesy SCDNR.

**Page 38** – Top photo: A close-up of the same crab and coral as in the last 2 images. This crab species was fairly common. Bottom photo: An Acanthogorgiid that was collected is shown here on the lab bench ready for preservation and counting of epifauna. Chirostylid crabs, anemones, Asteroschema - the unbranched basket star, and polychaetes were the most common epifauna. Photos courtesy Amy Baco-Taylor; Thomas Shirley; pilots T. Kerby and M. Cremer; and NOAA.

**Page 39** – The *Asteroschema* were also on many species of corals. On this bamboo coral, there were 6 large *Asteroschema*. You can see their long, yellow arms on the back of the colony and several more in the coral on the right. Photo courtesy Amy Baco-Taylor; Thomas Shirley; pilots T. Kerby and M. Cremer; and NOAA.



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